National Park Service
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Natural Resource Stewardship and Science

Vegetation Classification and Mapping of Hot Springs National Park, Arkansas

Project Report

Natural Resource Report NPS/HTLN/NRR—2015/1075

ON THE COVER
Hot Springs National Park
Photograph by: Lee Elliott, MoRAP

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David D. Diamond[1]*
Lee F. Elliott[1]
Michael D. DeBacker[2]
Kevin M. James[2]
Dyanna L. Pursell[1]
Alicia Struckhoff[1]

[1]Missouri Resource Assessment Partnership (MoRAP)
School of Natural Resources
University of Missouri
4200 New Haven Road
Columbia, MO 65201

[2]National Park Service
Heartland I&M Network
6424 West Farm Road 182
Republic, MO 65738

*contact diamondd@missouri.edu

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Abstract/Executive Summary

Hot Springs National Park (HOSP) is situated in central Arkansas, near the city of Hot Springs. In 1832, President Andrew Jackson created the first national park here when he signed legislation declaring "…four sections of land including said (hot) springs, reserved for the future disposal of the United States (which) shall not be entered, located, or appropriated, for any other purpose whatsoever."

A vegetation classification and mapping project was initiated in 2012 and completed in 2015. Protocols and products were produced following National Park Service Vegetation Inventory Program guidelines. Classification was based on 74 field plots and 96 georeferenced observation points. Mapping was based on air photo interpretation and heads-up digitizing of polygons. Accuracy assessment points obtained during 2014 verified that the map was 79.1% accurate.

Seven vegetation types were classified and mapped. Most of the area of the park was covered by dry or dry-mesic oak and pine-oak woodland and forest types. These communities together accounted for 75.8% of the area of the natural vegetation of the park. Pine types made up 56.0% of the area and oak types made up 19.7%. The single largest type was the Shortleaf Pine – Oak Dry-Mesic Woodland, which accounted for 35.7% of the area of the park. Dry woodland and forest occurred primarily on well-drained ridges and on south facing slopes, whereas dry-mesic forest occurred on north facing slopes. Intermittent upland drainages supported the Ouachita-Ozark Small Stream Hardwood Forest type, and accounted for 22.5% of the park. Ouachita Novaculite Glades accounted for only 8.3 acres (3.3 hectares) within the park, but these were unique communities in terms of vegetation structure and species composition. The communities within the park were strongly associated with abiotic variables, and since the topography features long ridges with steep slopes and high-gradient drainages, the communities were often situated in linear patterns that conformed to the long, northeast- to southwest-trending ridges and valleys.

Introduction

Hot Springs National Park Vegetation Inventory Project

Hot Springs National Park (HOSP) Vegetation Inventory Project was a cooperative initiative involving the Missouri Resource Assessment Partnership (MoRAP) at the University of Missouri, the Heartland Inventory and Monitoring Program (HTLN) of the National Park Service (NPS), and park managers and resource specialists. MoRAP provided the classification and mapping and HTLN provided accuracy assessment and overall project coordination. All aspects of the project conform to overall requirements set forward by the NPS Vegetation Inventory Program (see http://science.nature.nps.gov/im/inventory/veg/index.cfm).

The project was initiated because accurate maps of existing vegetation facilitate natural and cultural resource management and interpretation. HOSP supports mature oak and pine-oak forests in a rugged landscape that features long ridges and seep-sided slopes leading to deep valleys (Dale and Ware 1999, Dale and Watts 1986, James 2008). Each NPS Vegetation Inventory Project has three major components: classification, mapping, and map accuracy assessment. This report provides details on each of these fundamental elements.

NPS Vegetation Inventory Program

The National Vegetation Inventory Program (VIP) was established to map, classify, and describe vegetation in National Park units. It is administered by the NPS Biological Resources Management Division and provides baseline vegetation information to the NPS Natural Resource Inventory and Monitoring Program (I&M).

Vegetation Inventory Program scientists have developed procedures for classification, mapping, and accuracy assessment (Lea and Curtis 2010, Lea 2011). Use of the National Vegetation Classification System (NVCS) as the standard classification is central to fulfilling the goals of this national program. This system:

- is vegetation based;
- uses a systematic approach to classify a continuum;
- emphasizes natural and existing vegetation;
- uses a combined physiognomic-floristic hierarchy;
- identifies vegetation units based on both qualitative and quantitative data; and
- is appropriate for mapping at multiple scales.

The use of the NVCS and the establishment of classification and mapping standards facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs. In addition they can be used to provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental conditions and ecological processes across the landscape.

Before 1994, NVCS development was led by The Nature Conservancy (TNC), and further development was then passed on to the newly formed NatureServe organization. A network of state and regional ecologists involving dozens of individuals worked on the classification (TNC and ESRI 1994, Grossman et al. 1998). The NVCS is currently supported and endorsed by multiple federal agencies, the Federal Geographic Data Committee (FGDC 2008), NatureServe, state heritage programs, and the Ecological Society of America. Refinements to the classification have occurred in fits and spurts over the past decade, with funding from various federal and state agencies. A formal process for review of proposed revisions is in place (see Jennings et al. 2009), and the most accessible source for the NVCS is provided by NatureServe Explorer (http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol).

Vegetation Mapping Program Standards

The NPS I&M Program established guidance and standards for all vegetation mapping projects in a series of documents.

Protocols

- documenting a National Vegetation Classification System (TNC and ESRI 1994)
- standards for field methods and mapping procedures (Jennings et al. 2009, Lea 2011)
- producing rigorous and consistent accuracy assessment procedures (Lea and Curtis 2010)
- establishing standards for using existing vegetation data (TNC 1996)

Standards

- National Vegetation Classification Standard (FGDC 2008)
- Spatial Data Transfer Standard (FGDC 1998)
- Content Standard for Digital Geospatial Metadata (FGDC 1998)
- United States National Map Accuracy Standards (USGS 1999)
- Integrated Taxonomic Information System (http://www.itis.gov/)
- program-defined standards for map attribute accuracy and minimum mapping unit

A 12-step guidance document provides details that cover the entire process with links to information extracted or summarized from publications described above (National Parks Service 2011, available at http://science.nature.nps.gov/im/inventory/veg/docs/Veg_Inv_12step_Guidance_v1.1.pdf). Product specifications are also provided in a document (National Park Service 2011a, available at http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf).

Hot Springs National Park

Hot Springs National Park (HOSP) is located near the city of Hot Springs, Arkansas (Figure 1), and consists of 5477.9 acres (2,216.9 ha). The site was established in 1832 as the first national park, preceding Yellowstone by 40 years (National Park Service 1986). The original intent was to conserve the natural hot springs water. The hot springs are among the most significant natural resources of the park. According to the U.S. Environmental Protection Agency, most of HOSP is in the Central Mountain Ranges Level IV ecoregion of the Ouachita Mountains Level III ecoregion. A small

portion of the northeast is in the less rugged Central Hills, Ridges, and Valleys Level IV ecoregion. The vegetation has long been recognized as representing some areas of mature pine and pine-oak forest and woodland (Dale and Ware 1999, Dale and Watts 1980, National Park Service 1998, Witsell 2003). Dale and Ware (1999) concluded that the forests of HOSP were typical of the Ouachitas in general, and that the distributions of deciduous trees, but not pines, were correlated with aspect and topography.

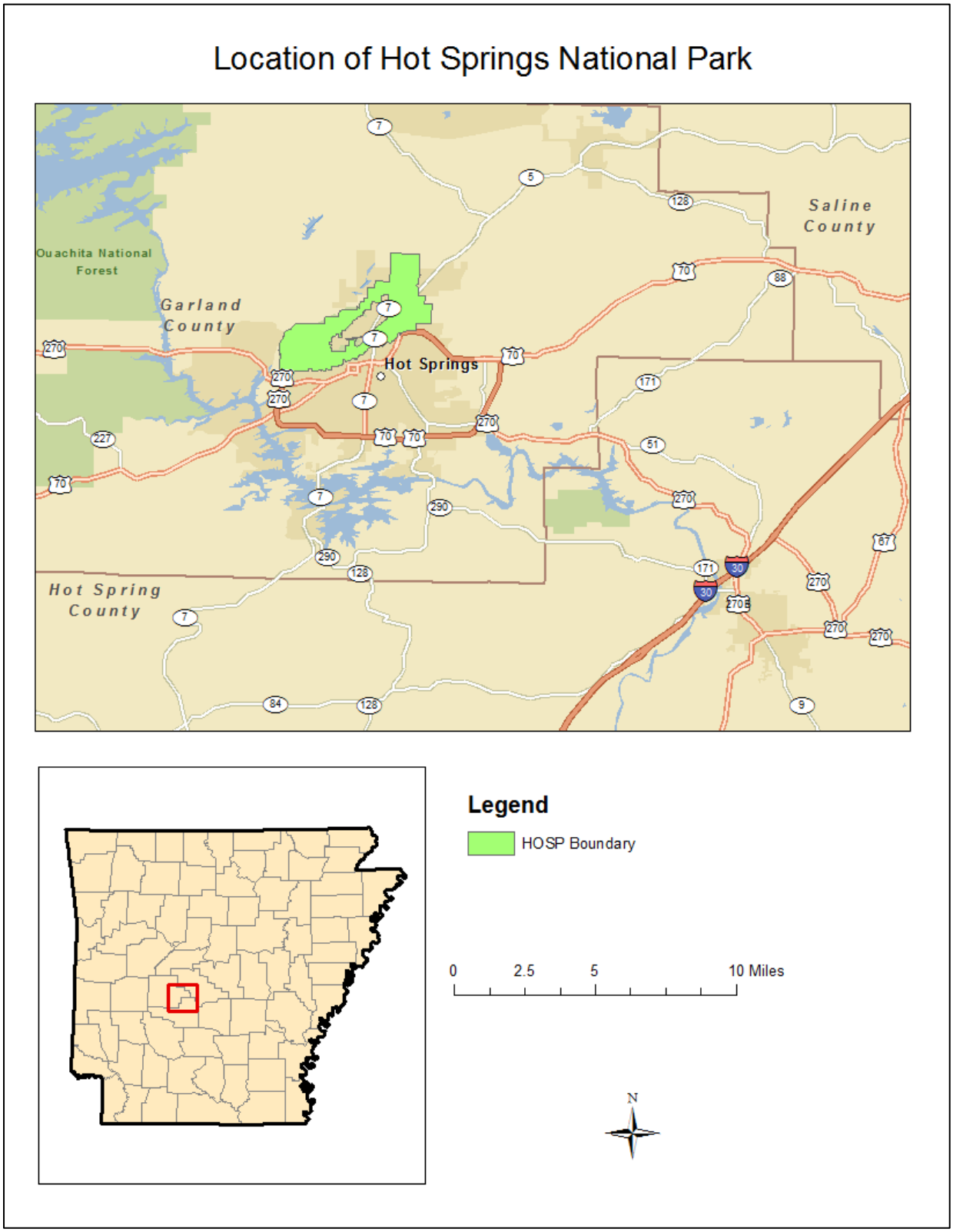

Figure 1. Location of Hot Springs National Park.

Project Statistics

Field Work 2012 - 2014:

Plot Sampling = 74

Plots sampled in May 2013 by MoRAP staff

Accuracy Assessment Points = 137

All collected in September 2014 by Heartland Inventory and Monitoring Network staff

Observation Points = 96

Collected in November 2012 and May of 2013 by MoRAP staff

Classification:

6 NVC Plant Associations
1 Park Special Vegetation Class
1 Non-Vegetated Land-Use Class (not including water)

GIS Database 2012 - 2014:

Hot Springs National Park = 5,465 acres (2,211.8 hectares)

Base Imagery used for mapping (acquired by MoRAP):

2010, Arkansas County, AR, leaf-on, true color, 1m
2006, Arkansas County, AR, leaf-off, CIR, 1m

Additional Imagery acquired and viewed by MoRAP:

SPOT, leaf on
SPOT, leaf off

Minimum Mapping Unit = 0.5 hectare
Minimum Patch Size = 0.01 hectares
Total Size = 1402 Polygons
Average Polygon Size = 3.92 acres (1.58 hectares)
Overall Thematic Accuracy = 79.1%
Project Completion Date: 08/2015

Methods

Hot Springs National Park, at 5,465 acres, is a medium sized park as defined by sampling design protocols (TNC and ESRI 1994). The sampling design was aimed at representing the major abiotic gradients and land covers present in the park. These included mainly deciduous tree cover and mixed pine-deciduous or mainly pine tree cover on all slopes, aspects, and land positions. In addition, limited areas of more open canopy or grasses within the forest were targeted for sampling. Since access to private lands outside of the park was not ensured, the project boundary consisted of the boundary of the park itself (Figure 2). Five major tasks were identified and completed, including:

1. Plan, gather data, and coordinate tasks;

2. Survey HOSP to understand and sample the vegetation;

3. Classify the vegetation using the field data to NVC standard associations and alliances and crosswalk these to recognizable map units as far as possible;

4. Acquire current digital imagery and interpret the vegetation from these using the classification scheme and a map unit crosswalk; and

5. Assess the accuracy of the final map product.

All protocols for this project are outlined by NPS and important sections are summarized or linked at http://science.nature.nps.gov/im/inventory/veg/index.cfm). Drilling down to additional linked documents can be accomplished via the link to the National Park Service 12-step guidance document on that web site (National Park Service 2011). Important references include TNC and ESRI (1994), Jennings et al. (2009), Lea (2011), and Lea and Curtis (2010).

Planning, Data Gathering, and Coordination

The vegetation mapping project was discussed with appropriate park staff in coordination with Heartland Network staff and MoRAP staff. A proposal for vegetation mapping was subsequently completed and approved by NPS National Vegetation Inventory Program staff. Based on that proposal, MoRAP was responsible for classification, plot sampling, mapping, and development of digital databases. The Heartland Network was responsible for oversight of MoRAP activities in concert with NPS Vegetation Inventory Program staff, and coordinated Accuracy Assessment (AA) tasks. HOSP staff provided logistical and technical support, and helped coordinate field activities.

Field Survey

The field methods used in sampling and classifying the vegetation followed the methodology outlined by the NPS Vegetation Inventory Program team (see Jennings et al. 2009, Lea 2011, National Park Service 2011). The application of these methods to HOSP is outlined below.

Digital soil survey information, surface geology maps, digital elevation models, and both current and historic air photos were initially reviewed, along with existing vegetation information (Dale and Ware 1999, James 2008). A rapid field assessment, including collection of georeferenced field

points, was made during November, 2012. Together, this body of information was used to plan quantitative field data collection (Figure 3). Observation points consisted of brief visits (fewer than 15 minutes) by ecologists from MoRAP where general information on vegetation structure and composition was noted.

Vegetation data were collected at 74 plots by MoRAP staff in May of 2013 (Figure 4). In the lab, the locations of plots were randomly placed within abiotic and vegetation cover strata based on initial field observations during November of 2012. The abiotic strata included, in general, mesic slopes, dry slopes, ridges, and creek bottoms. In addition, both pine-oak and oak vegetation was targeted for sampling within each abiotic stratum. Finally, open glades were recognized from air photos and ground surveys and were targets for sampling. Plots were located >30 m from an obvious land cover edge, and for each potential plot location there was at least one alternate, should the original point be determined unusable in the field (e.g. close to an un-mapped trail or road, stand too small). The stratified random plot location information was loaded into a GPS and workers navigated to the plot in the field for field sampling.

Woodlands and forests were sampled with a 10 m x 40 m plot (400 sq m), while the more open shrublands and grasslands were sampled with a 10 m x 20 m plot (200 sq m). Minimal flagging was used to mark the plot. Data were collected using a plot survey form (Appendix B). The survey form includes sections for plot location and description, as well as vegetation and environmental information about the plot.

Vegetation sampling included information about structure and physiognomy, with leaf phenology, leaf type, and physiognomic class recorded for the dominant vegetative stratum. Cover data was collected for the following strata, where applicable.

T1 = Emergent Tree (overstory) >30 m
T2 = Tree Canopy (overstory) 20-30 m
T3 = Tree Subcanopy (midstory) 5-20 m
S1 = Tall Shrub (understory woody species, tree and shrub) 1-5 m
S2 = Short Shrub (woody species, tree and shrub) <1 m
H = Herbaceous species, does not include S2

Additionally, cover was recorded in modified Daubenmire (1959) cover classes for each species by strata (Table 1).

Table 1. Canopy cover used for quantitative sampling.

Cover Class Codes	Range of Cover (%)
7	95-100
6	75-95
5	50-75
4	25-50
3	5-25
2	1-5
1	0-0.99

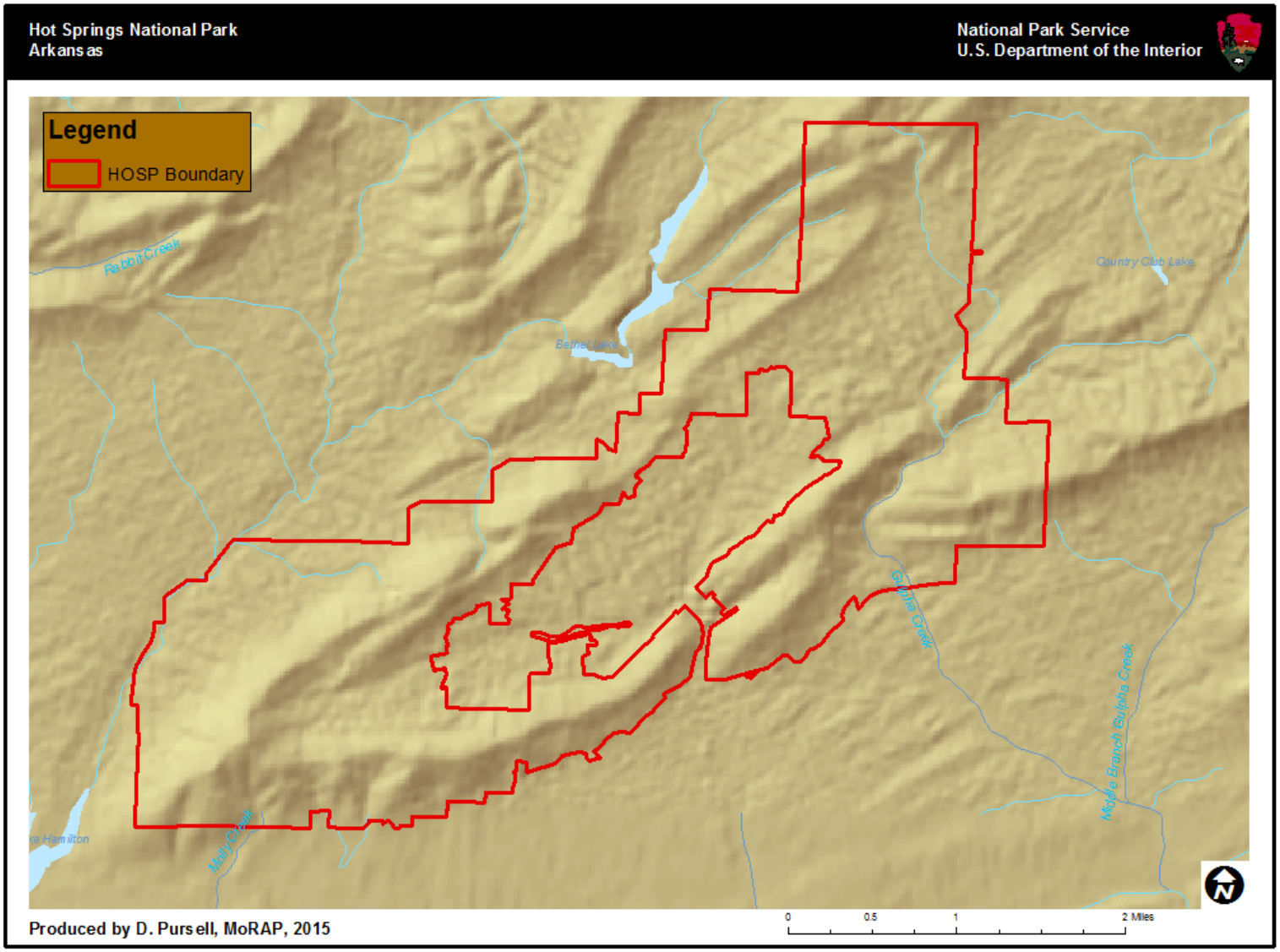

Figure 2. Map of Hot Springs National Park.

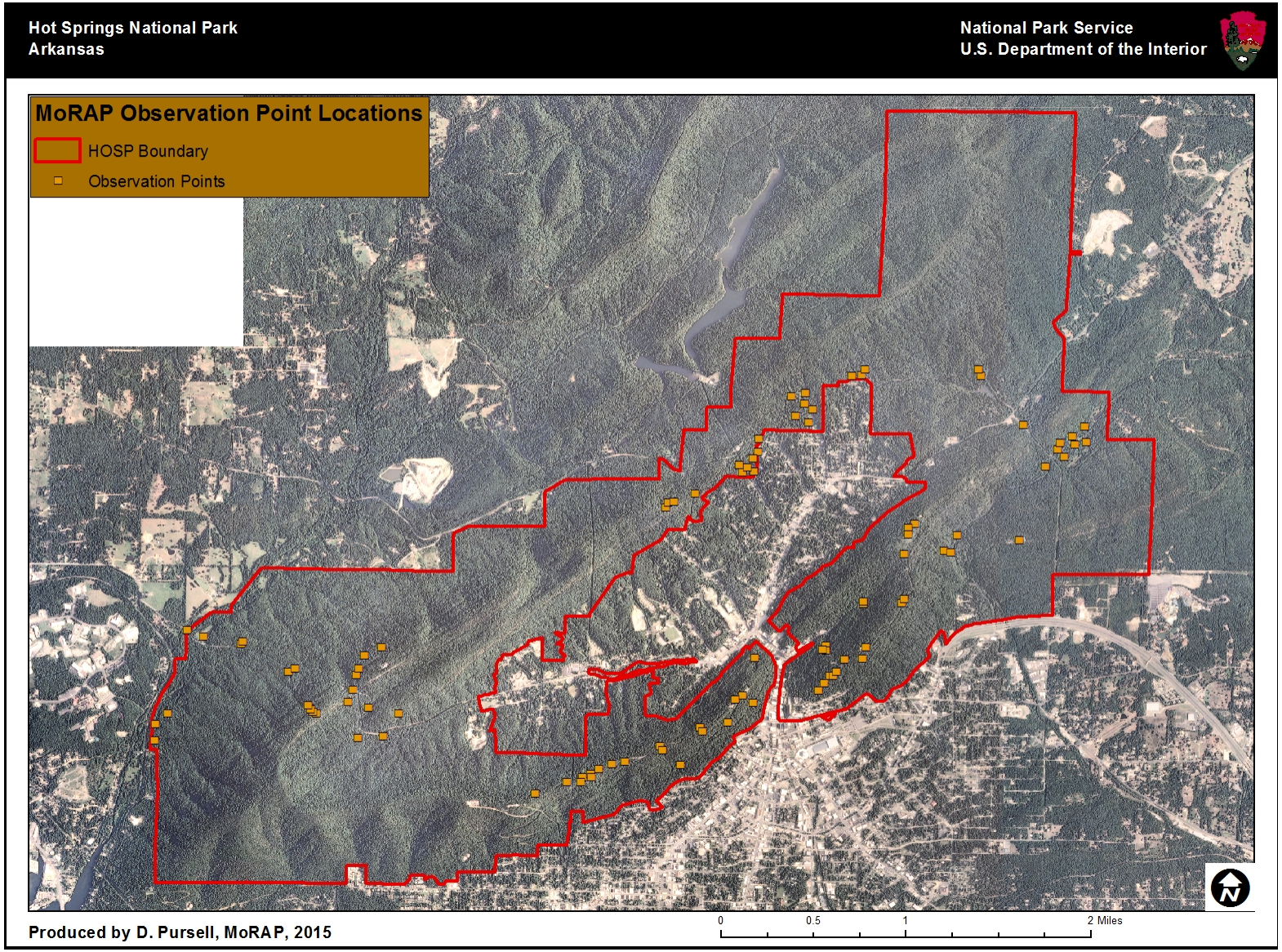

Figure 3. Map of 96 Observation Points at Hot Springs National Park.

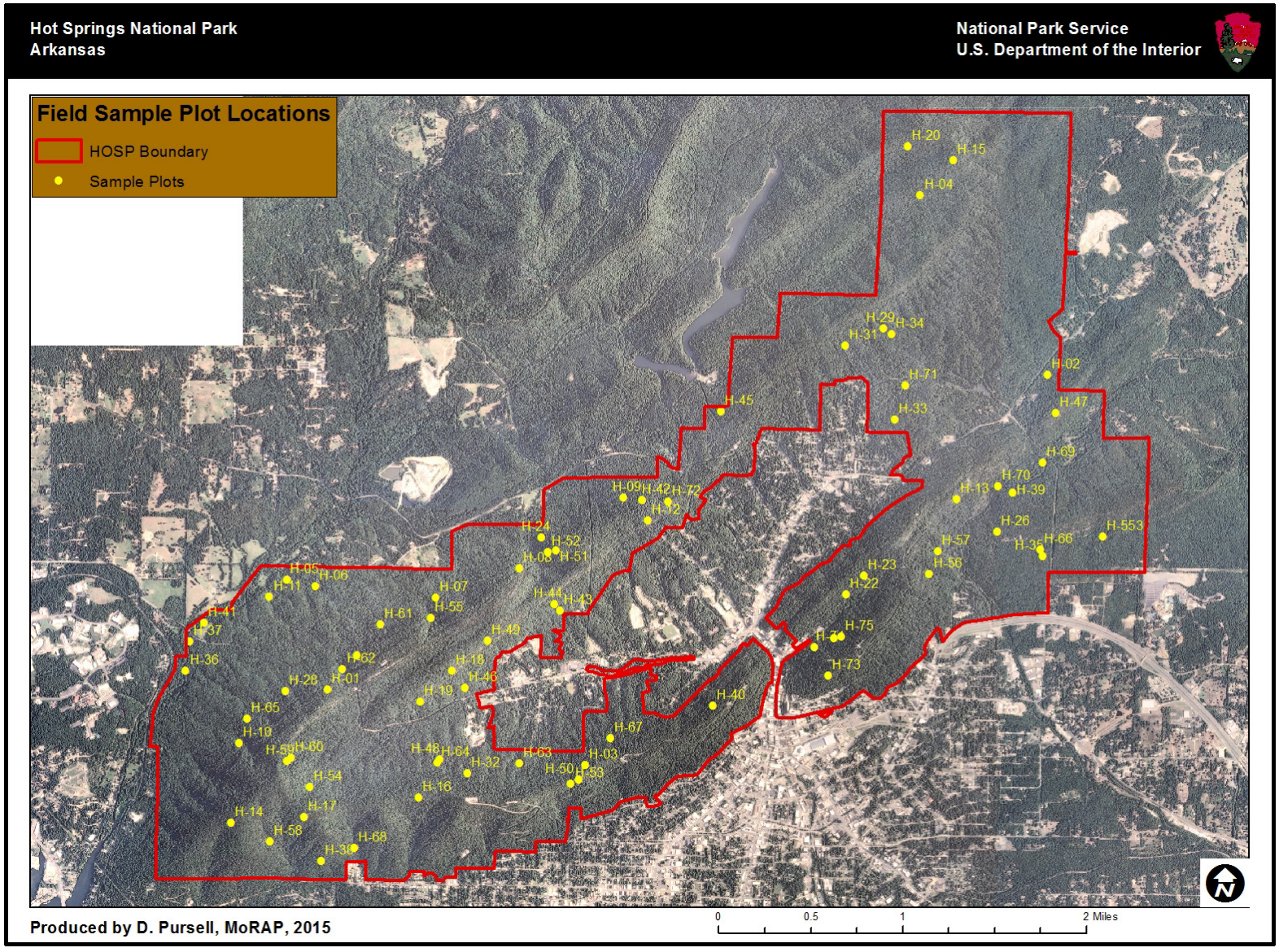

Figure 4. Map of 74 sample plots at Hot Springs National Park.

Vegetation Classification

All recorded data were entered into the NPS PLOTS v3 database (available at http://science.nature.nps.gov/im/inventory/veg/plots.cfm), a Microsoft Access-derived program. The PLOTS database was developed for the NPS National Vegetation Inventory Program so that data entry fields mirror the standard field form. Data entry was facilitated by assigning each plant taxon a unique, standardized code and name based on the PLANTS database developed by Natural Resources Conservation Service in cooperation with the Biota of North America Program (USDA and NRCS 2009, available at http://plants.usda.gov/java/). Data were thoroughly proofed after entry to minimize errors.

Digital Imagery and Interpretation

The mapping component was produced by identifying land cover on air photos and hand digitizing on-screen. Heads-up digitizing was accomplished at a display scale of not more than 1:1,000 against a back-drop of air photos. Imagery was the most recent available from the National Agriculture Imagery Program (NAIP; see http://www.fsa.usda.gov/Internet/FSA_File/naip_2009_info_final.pdf). This included 2010 leaf-on true color and 2006 leaf-on color infrared images (Figure 5). Additionally, georeferenced aerial photography from the 1940's, 1960's, 1980's, and 1990's were used to identify areas where previous disturbance had occurred, including demolished buildings, old roads, clearings, and historical timber harvest sites.

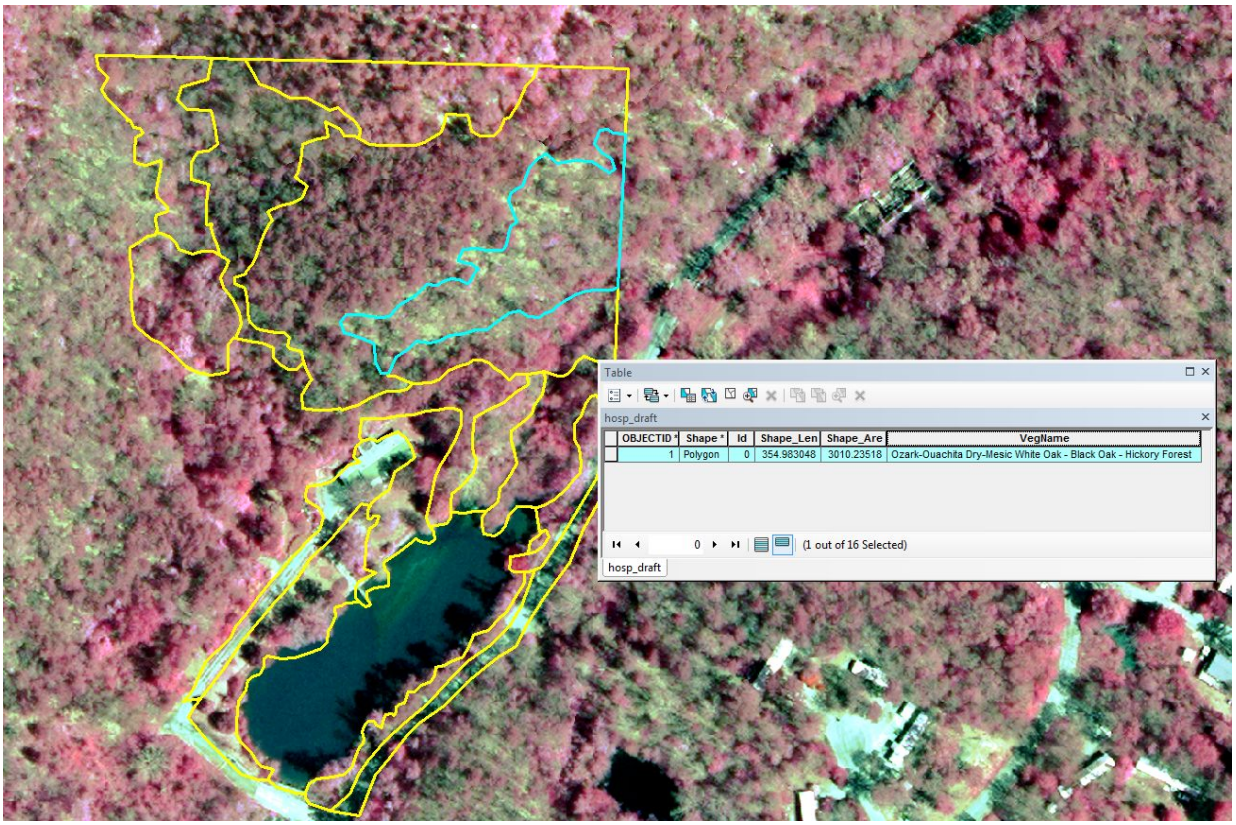

Figure 5. Digitization of hand drawn objects.

GIS

Using 10m DEM, we calculated elevation above channel (achan), slope, solar insolation (calculated between mar21 and oct21 once a week at 1 hr intervals), landscape position (using a neighborhood of 7) and topographic wetness index. We did a principal components analysis (PCA) on these 5 variables and used k-means on the PCA results to produce 12 classes. These were binned to most faithfully represent the results from the plot classification. Many other methods were attempted, using SSURGO soils data, surficial geology, and each of the separate DEM derived abiotic variable above, alone, and in various combinations. The k-means method seemed to provide the best result. K-means classes were then overlaid with hand delineated polygons that had been attributed with landcover (primarily deciduous forest vs. evergreen forest) to further differentiate the map classes. The resulting layer was adjusted by hand, particularly with respect to Cultural, Disturbance Woodland and Forest, and Ouachita Novaculite Glade.

Initial Cluster

Ouachita Novaculite Glade (plots 50, 51, 52, and 53) and Disturbance Woodland (plot 69) were removed from the dataset prior to analysis because they were outliers and differed markedly relative to tree canopy cover (glades) or composition (disturbance woodland).

Plot data were subject to cluster analysis and ordination in order to help inform classification. Species-specific data were collected in multiple strata using cover classes, but for the purpose of analysis, the cover values for each species were combined into a single value using the midpoint of the cover class. The formula for percent overlap used to combine the strata cover values for each species was

$$1 - \prod(1 - \frac{\%cover}{100}).$$

Use of this formula reduces the effects of overlapping cover in various strata. We used a log transformation to standardize cover values using the formula log(cover + 1). Bray-Curtis dissimilarity was used as the distance metric for the cluster and ordination analyses (Legendre and Legendre 1998). Clustering was performed using the hierarchical clustering algorithm known as flexible Beta with a $\beta = -0.25$ (Lance and Williams 1967, Maechler et al. 2011). Non-metric multidimensional scaling was used to develop the ordination (Legendre and Legendre 1998, Roberts 2010).

Descriptive information on NVC community composition concepts and classification were obtained from the NatureServe Explorer (2013) website available at http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol. One disturbance woodland not found in the NVC was defined.

The initial clustering identified four main classes as shown in Figure 6. The far left cluster (red) generally represents dry-mesic deciduous forest, the blue cluster represents dry-mesic mixed and evergreen forest, the green cluster represents riparian forest, and the far right (yellow) cluster represents dry forest. The far right (yellow) cluster was further differentiated into two types,

deciduous and mixed/evergreen. Plot membership in these groups were modified based on plot-by-plot inspection of species composition (focusing on feasibility of differentiating using a composition based field key) and plot location within the abiotic partitions of the landscape.

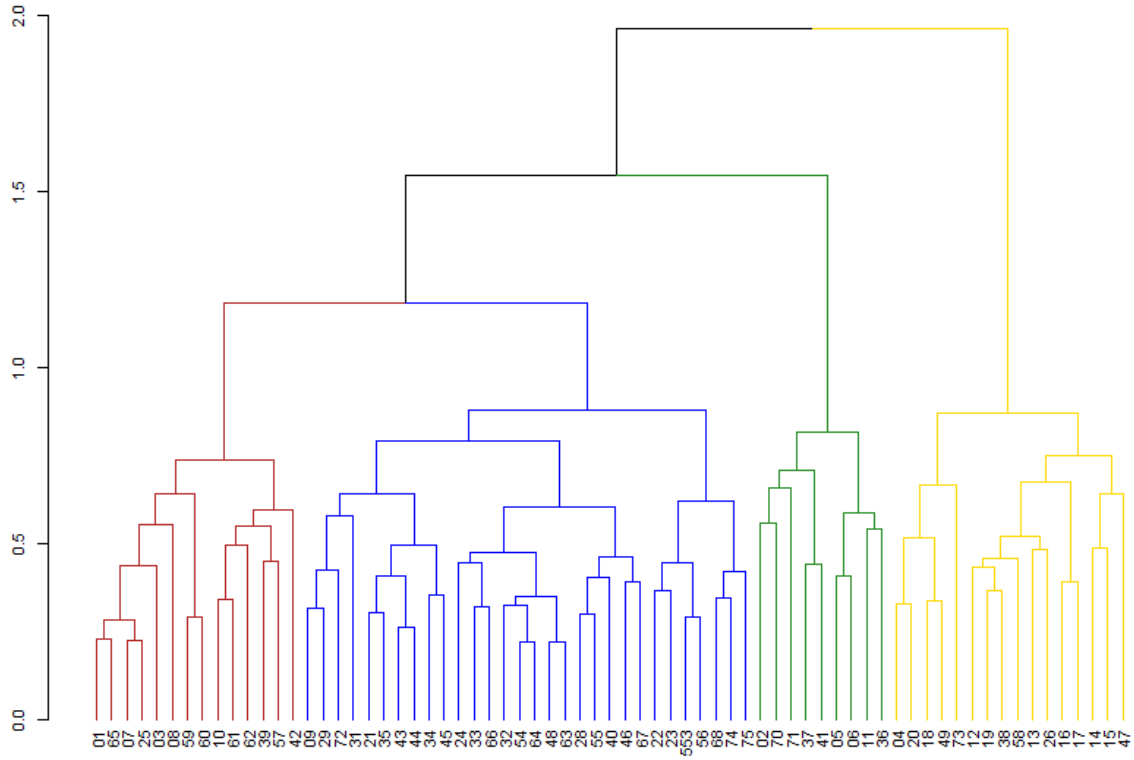

Figure 6. Illustration of Flexible Beta cluster analysis for plot data. Numbers across bottom indicate plot identification. Colored leaves represent 4 main cluster results.

The results of this cluster analysis were used to interpret the non-metric multidimensional scaling ordination that was also performed on the transformed data. The results of the ordination, using the same color scheme as presented for the cluster analysis are shown in Figure 7 (axes 1 and 2) and Figure 8 (axes 1 and 3). The further differentiation of the yellow cluster is indicated by the darker (orange) representations on the ordination figures. These results reflect the close relationship between dry-mesic forest and riparian forest, which proved difficult to differentiate when developing a field key based on composition.

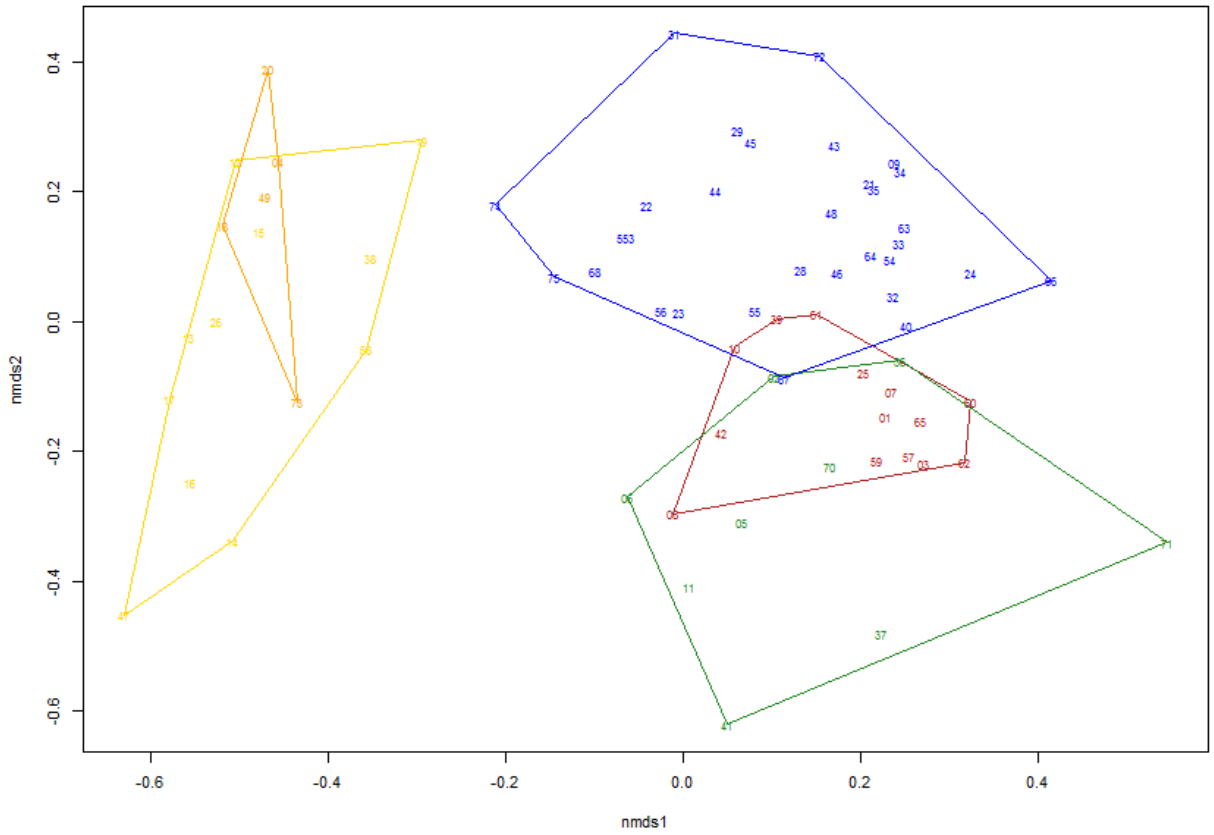

Figure 7. Results of non-metric multidimensional scaling ordination (axes 1 and 2). With colors of plot labels and polygon borders reflecting cluster membership from analysis above. Yellow coded cluster is split into two classes (yellow and orange).

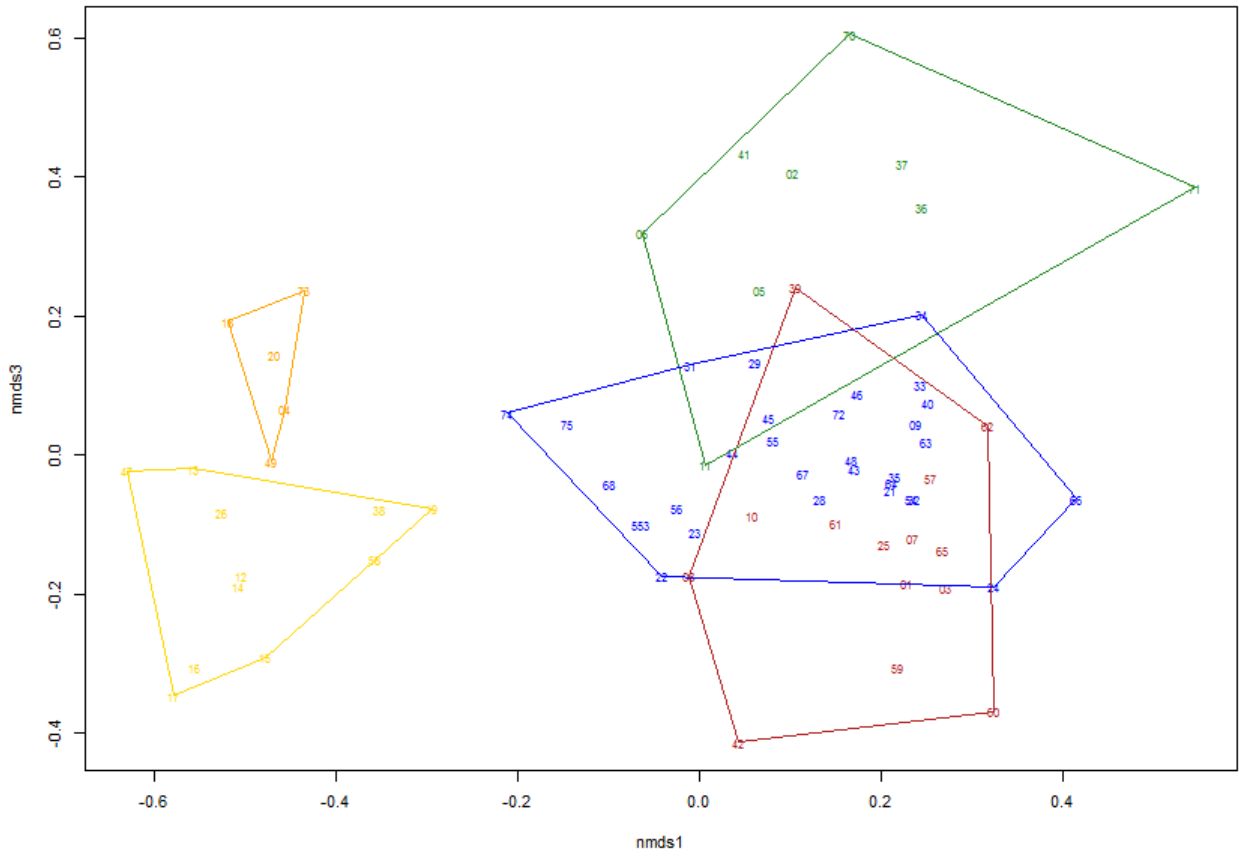

Figure 8. Results of non-metric multidimensional scaling ordination (axes 1 and 3). With colors of plot labels and polygon borders reflecting cluster membership from analysis above. Yellow coded cluster is split into two classes (yellow and orange).

To give some perspective to the ordination results, we generated surfaces (Figure 9) for 3 characteristic species of the plots, post oak (*Quercus marilandica),* generally occupying drier sites, sweetgum (*Liquidambar styraciflua),* generally occupying wetter sites, and shortleaf pine (*Pinus echinata),* occupying sites across the moisture gradient. Surfaces were generated by using a generalized additive model to fit quantitative cover to the ordination coordinates and predicting values at all grid points (function 'surf' in the labdsv package of the statistics package R; *http://ecology.msu.montana.edu/labdsv/R*).

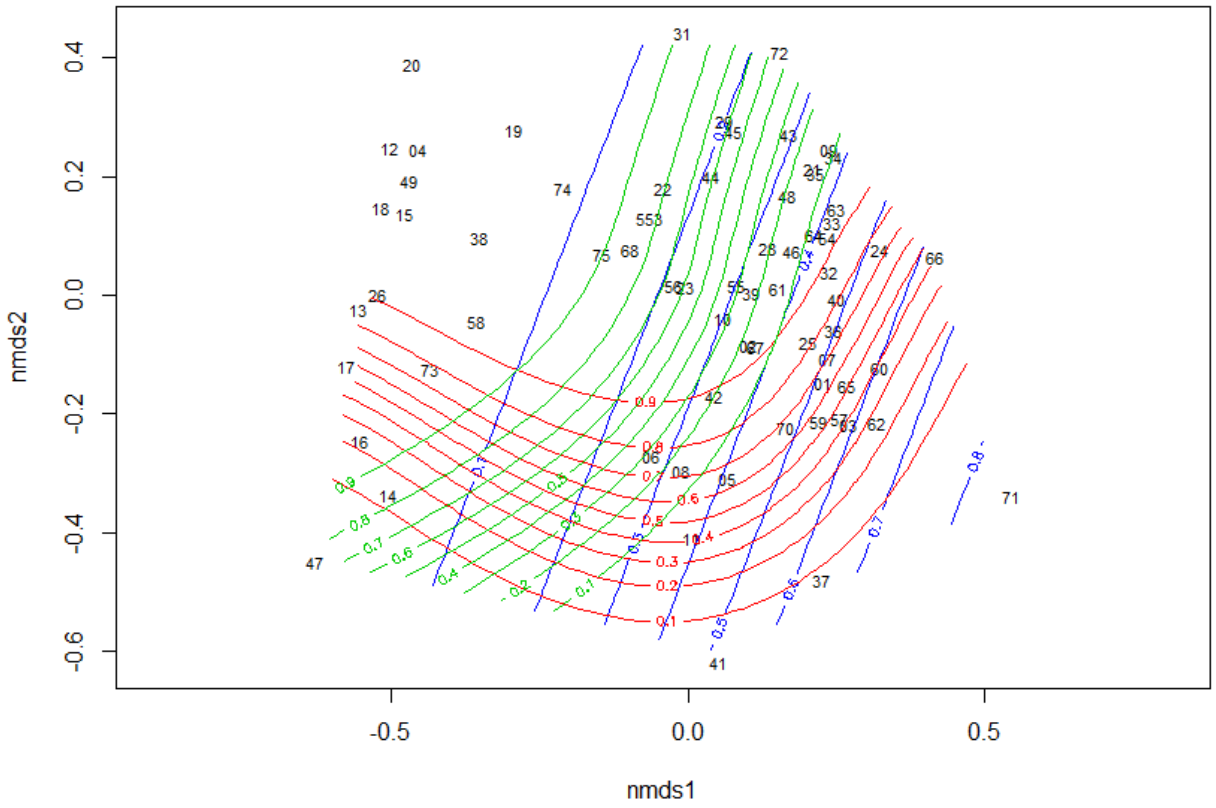

Figure 9. Results of non-metric multidimensional scaling ordination with fitted surfaces for *Quercus marilandica* (green, increasing toward upper left corner of ordination), *Pinus echinata* (red, decreasing towards lower middle of ordination), and *Liquidambar styraciflua* (blue, increasing towards lower right corner of ordination).

Several plots were moved to different classes following plot-by-plot analysis of the composition and relationship of the plots to the abiotic characterization of the landscape. The overlay of the classification as mapped is depicted in Figure 10, which is a 3 dimensional representation of the ordination with coloring retained from initial cluster results.

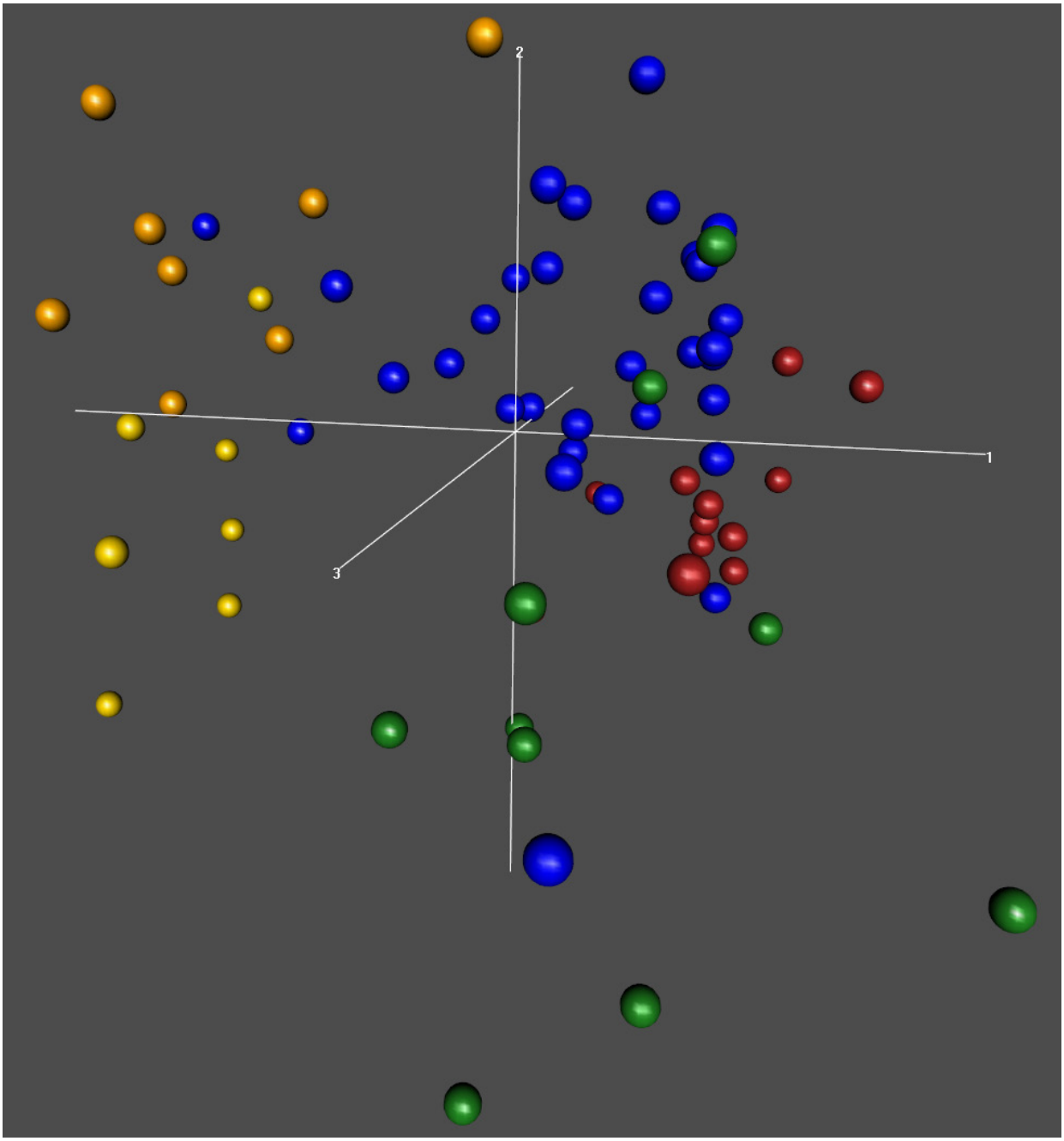

Figure 10. 3D representation of non-metric multidimensional scaling ordination using the same ordination scores, but colored to conform to the plots as they were classed during mapping. Color codes follow previous colors as presented in the cluster analysis above.

Once the classification was finalized, a dichotomous key was developed by MoRAP for use during the AA (Appendix C). For types with an NVC assignment, the full NVC hierarchical classification and global descriptions are available in the results section. In addition, the final described types were linked to map classes for use in the photo-interpretation and mapping portions of the project.

Accuracy Assessment

Thematic accuracy assessment was conducted by HTLN. Methods and analysis for the accuracy assessment of vegetation mapping at HOSP were based on NPS standards (Lea and Curtis 2010). Thematic accuracy assessment of mapped vegetation classes were assessed independently following the completion of the vegetation mapping inventory by the lead authors.

Representative sites were identified and visited in the field to determine if interpreted mapped classes were correctly assigned by field observers using the dichotomous key to mapped current vegetation types (Appendix C). Identifying the degree of correspondence between field observations and mapped attributes provides a measure of the map's suitability for different applications.

Accuracy assessment consisted of first evaluating the spatial pattern (total area and number of polygons) of each mapped vegetation class. The number of samples in each class was selected from five possible scenarios (Table 2). Accuracy assessment was restricted to natural vegetation map classes, thus omitting developed areas and standing water. Once the appropriate sampling scenario for each map class was determined, site selection was performed using a geographical information system (ArcGIS 10.0).

Table 2. Target number of Accuracy Assessment samples per map class based on number of polygons and area.

Scenario	Description	Polygons in class	Area occupied by class	Recommended number of samples in class
Scenario A:	The class is abundant. It covers more than 50 hectares of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.	>30	>50 ha	30
Scenario B:	The class is relatively abundant. It covers more than 50 hectares of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.	<30	>50 ha	20
Scenario C:	The class is relatively rare. It covers less than 50 hectares of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.	>30	<50 ha	20

Table 2. Target number of Accuracy Assessment samples per map class based on number of polygons and area (continued).

Scenario	Description	Polygons in class	Area occupied by class	Recommended number of samples in class
Scenario D:	The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 hectares of the area. In this case, the recommended number of samples is 5. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than 5 sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting 5 sample sites will allow an accuracy estimate to be computed, although it will not be very precise.	5 - 30	<50 ha	5
Scenario E:	The class is very rare. It has fewer than 5 polygons and occupies less than 50 hectares of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon) no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).	<5	<50 ha	Visit all and confirm

Random sample points were generated in ArcGIS. Points were buffered 40 meters from the park boundary and 80 meters from another point. The minimum mapping unit used in delineating vegetation polygons was 0.5 hectare. All random points were selected within the park boundary to avoid any private land issues.

Randomly selected site locations were loaded onto a Garmin GPS unit for field navigation (Figure 6). All accuracy assessment field work was completed on June 26, 2012. Field staff was provided with a GPS unit, dichotomous key for mapping vegetation map classes and vegetation class definitions.

Plot shape and size varied according to the extent of the vegetation class patch containing the sample point. Circular 0.25 hectare (28 m radius) plots were used for larger patches while rectangular 0.1 hectare (18 m radius) plots were used for small patches approaching the minimum mapping unit. A circular plot size of 0.5 hectare (40 m radius) was used to capture information for a single large homogenous patch. In all cases, plot size exceeded the minimum patch size for HOSP.

Field staff recorded plot size and shape, positional accuracy and vegetation classification at each point (Accuracy assessment field form, Appendix D). In addition, comments regarding the plot

location, plot size and vegetation were recorded on the field form. Field data from the 137 points were entered into to the PLOTS database and underwent quality assurance/quality control (QA/QC) verification. In addition, the associated project geodatabase was updated in ArcGIS to reflect any changes to the point location due to offsets made in the field. All classification and spatial field observations were compared with the vegetation map and AA point locations for any differences.

Upon completion of QA/QC, the accuracy assessment analysis was performed. All analysis and evaluation of producer and user accuracy was conducted using the AA Contingency Table Calculation Spreadsheet (http://science.nature.nps.gov/im/inventory/veg/guidance.cfm). Statistics and calculations performed in the spreadsheet are presented in Table 3.

Table 3. Summary of the Accuracy Assessment statistics used at Hot Springs National Park.

Statistic	Description
User's Accuracy	The fraction of the accuracy assessment observations in a map class that were found to have the correct vegetation class in the field.
Producer's Accuracy	The fraction of the accuracy assessment observations in a vegetation class in the field that were found to be mapped correctly.
Overall Accuracy	The fraction of accuracy assessment observations within all map classes that were correctly mapped.
Kappa Index	Another measure of overall accuracy, which takes into account the probability that mapped polygons will be correct due to random chance.

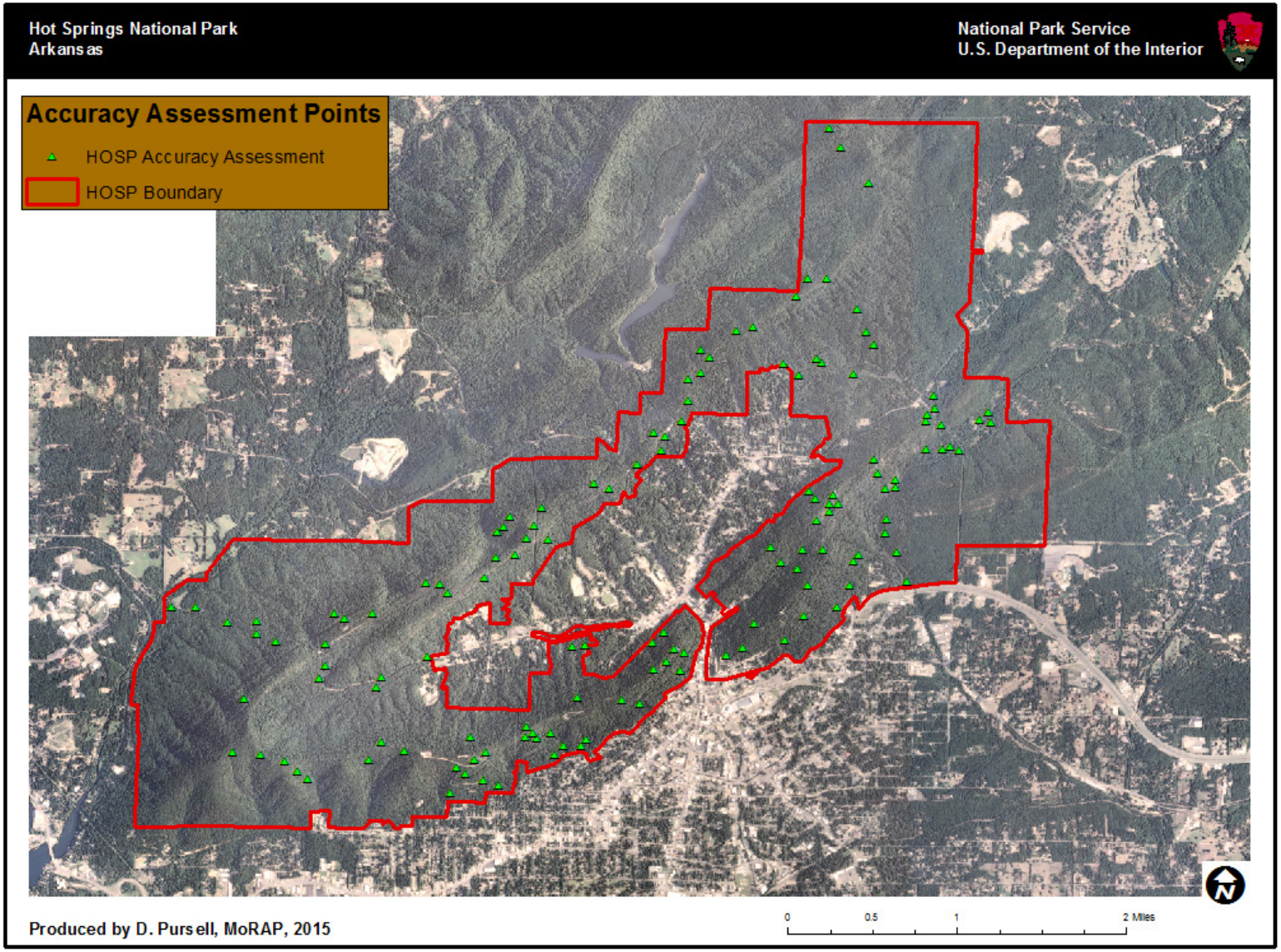

Figure 11. Accuracy assessment points for Hot Springs National Park.

Results

Vegetation Classification

Seven vegetation types were identified at HOSP based on ordination and cluster analysis results (Table 4). These types corresponded with environmental gradients (ridges, dry slopes, mesic slopes, bottoms) and land cover (evergreen and mixed forest and woodland, deciduous forest and woodland, and open woodland/grassland). The major oak and oak-pine communities conformed to descriptions of the prevailing associations common across the Ouachita and Ozark ecoregions. One type, the Ouachita Novaculite Glade, was uncommon and of limited distribution. This type is found only on outcrops of Novaculite in the Ouachita Mountains. Only one type, the Disturbance Woodland and Forest, could not be assigned to a recognizable plant association described in the National Vegetation Classification. This community was found on and near old home sites that have been removed around the edges of the park boundary.

Digital Imagery and Interpretation

Seven terrestrial map units that corresponded directly with the classified vegetation were defined (Table 4). The developed land map class was a catch-all that included all areas without semi-natural vegetation.

Vegetation Map

The standard minimum mapping unit for NPS vegetation mapping projects is defined as 0.5 hectare, although several mapped polygons were smaller for HOSP. The vegetation map reveals that the distribution of communities generally conforms to the lay of the land (Figure 12). Communities often follow long ridges and side slopes and are thus distributed in a linear fashion. The Shortleaf Pine – Oak Dry-Mesic Woodland type was most abundant at HOSP, covering 35.7% of the area, exclusive of cultural areas and water. The Ouachita-Ozark Small Stream Hardwood Forest was second in area, followed closely by the Ozark/Ouachita Shortleaf Pine – Oak Dry Woodland, at about 20% of the area each. The Ozark/Ouachita Dry-Mesic White Oak – Black Oak – Hickory Forest accounted for 11.4% of the area. The Ouachita Novaculite Glade only covered 3.3 hectares, but this unique type was among the only areas of the park without a continuous woody canopy.

Table 4. Mapped types identified at Hot Springs National Park.

NVC Identifier	Mapped Type Name	Scientific Name / Description	Number of Polygons	Acres	Hectares
		Forest and Woodlands			
CEGL007825	Ouachita Novaculite Glade	*Quercus marilandica* var. *ashei* / *Schizachyrium scoparium - Andropogon gerardii - Monarda fistulosa* var. *stipitatoglandulosa - Streptanthus maculatus* / Lichens Novaculite Glade Wooded Herbaceous Vegetation	27	8.3	3.3
CEGL007826	Ouachita-Ozark Small Stream Hardwood Forest	*Liquidambar styraciflua - (Quercus alba, Acer saccharu*m / *Carpinus caroliniana* / *Lindera benzoin* Forest	227	1175.1	475.5
CEGL002149	Ozark/Ouachita Post Oak - Blackjack Oak / Little Bluestem Woodland	*Quercus stellata - Quercus marilandica - Quercus velutina - Carya texana / Schizachyrium scoparium* Woodland	137	431.0	174.4
CEGL002393	Ozark/Ouachita Shortleaf Pine - Oak Dry Woodland	*Pinus echinata - Quercus stellata - Quercus marilandica / Schizachyrium scoparium* Woodland	257	1064.1	430.7
CEGL004270	Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest	*Quercus alba - Quercus velutina - Carya alba / Desmodium nudiflorum* Ozark Forest	220	597.4	241.8
CEGL002394	Shortleaf Pine - Oak Dry-Mesic Woodland	*Pinus echinata - Quercus alba / Schizachyrium scoparium* Woodland	428	1861.7	753.4
		Non-native Forest / Shrubland / Mixed Vegetation			
Mixed; elements of CEGL003807; CEGL008568	Disturbance Woodland and Forest	Southeastern North American Semi-natural Forest Macrogroup; *Ligustrum sinense* Shrubland; *Wisteria sinensis* Shrubland	39	82.1	33.2
		Land Use/Land Cover			
	Cultural		53	242.8	98.2
	Open Water		14	15.4	6.2
Total Land Use/Land Cover			**67**	**258.1**	**104.5**
Total Natural Vegetation			**1335**	**5219.8**	**2112.4**
Totals			1402	5477.9	2216.9

Accuracy Assessment

The 2012 accuracy assessment for HOSP included the natural and semi-natural vegetation, which covered 2112.4 hectares (5219.8 acres). A total of 137 points were required to accurately evaluate the seven natural and semi-natural vegetation map classes identified in the park. Navigational error (positional accuracy) of the GPS unit ranged from 3 - 6 meters.

Overall accuracy of the final error matrix was 79.1% (the 90% confidence interval was between 72.8%and 85.4%) for the natural and semi-natural mapped vegetation types at HOSP (Appendix A). Omission accuracy (map producer's error) was >72.5% except for the very small Ouachita Novaculite Glade type, a small type that only occupied 3.3 hectares and had a Commission accuracy of 80.0%. Commission accuracy (user's error) was over 77% for all but two types: the Ozark/Ouachita Shortleaf Pine – Oak Dry Woodland (61.5%) and the Ouachita – Ozark Small Stream Hardwood Forest (64.7%). The Small Stream Hardwood type had an Omission accuracy of 100%. The Kappa Index, or the random chance polygons were assigned correctly, was 76.2% (Appendix A).

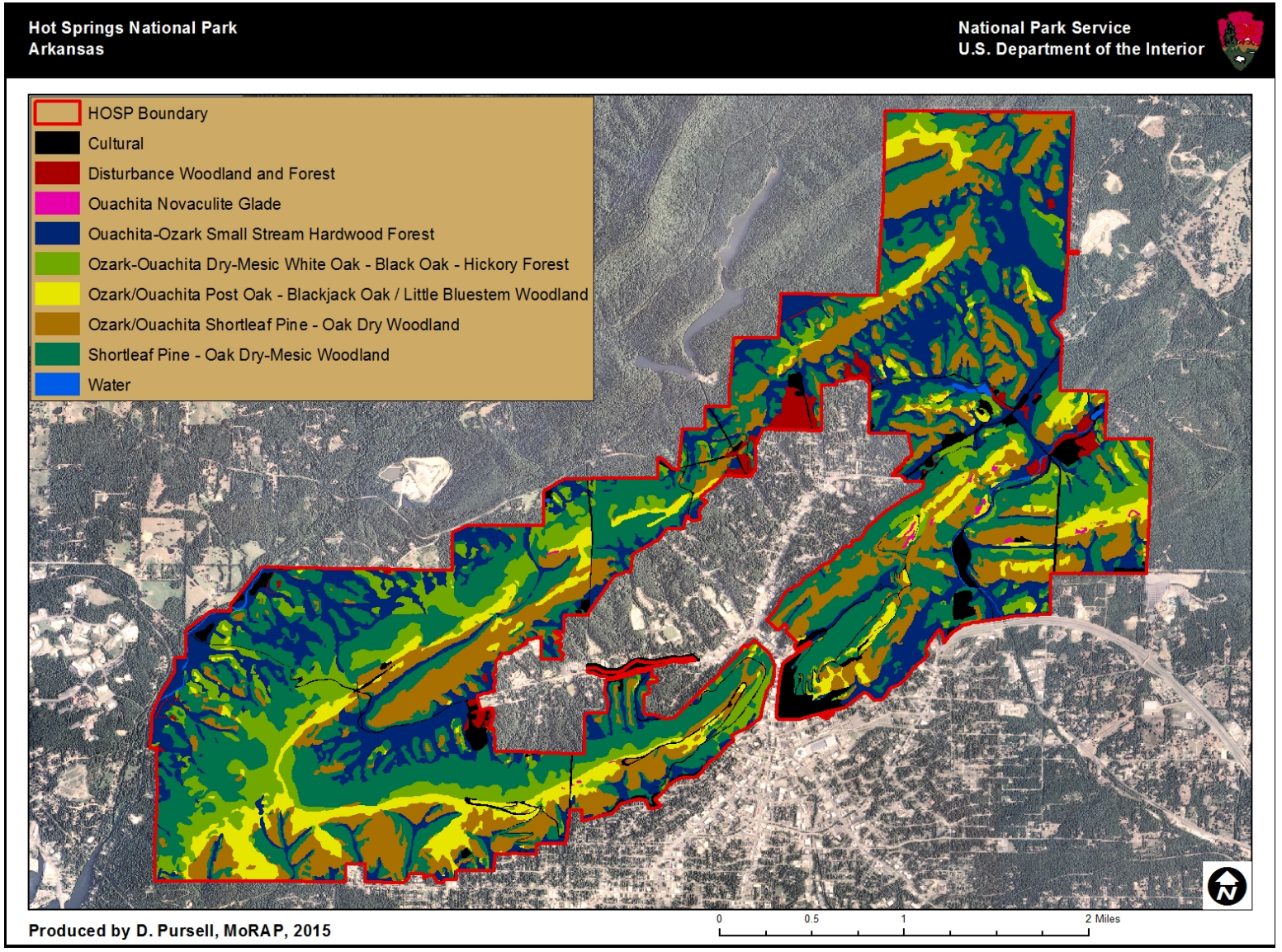

Figure 12. Vegetation classification for Hot Springs National Park.

Vegetation Associations

Mapped Type Name: Disturbance Woodland and Forest
Macrogroup: Mixed: Southeastern North American Semi-natural Forest; Southeastern Ruderal Grassland & Shrubland
Group: Mixed: Lobolly Pine Semi-natural Forest Group; Southeastern Ruderal Grassland & Shrubland
Association: Mixed: *Ligustrum sinense* Ruderal Upland Shrubland; *Wisteria sinense* Ruderal Vine-Shrubland; others
Type Common Name: Mixed Ruderal Types: Chinese Privet Ruderal Upland Shrubland; Chinese Wisteria Ruderal Vine-Shrubland; others
Type Scientific Name: Mixed: *Ligustrum sinense* Ruderal Upland Shrubland; *Wisteria sinense* Ruderal Vine-Shrubland; others

Figure 13. Disturbance Woodland and Forest vegetation occurred around former houses that have been removed at HOSP.

Global Summary: A wide variety of disturbance forests, woodlands, and shrublands occur across the southeast. Non-native and native early successional species dominate these communities, but they may share few species in common. These communities may occur as ruderal within natural or semi-natural landscapes, or may occur as secondary growth around abandoned homesteads. The *Ligustrum* shrubland association comprises upland and wetland areas heavily infested with the exotic *Ligustrum sinense,* sometimes to the exclusion of canopy trees. The vine-dominated *Wisteria sinense* vegetation is dominated by *Wisteria sinensis* or *Wisteria floribunda*, or most often hybrids of the two fast-growing vines native to Asia. The community is most commonly seen in fragmented landscapes near old homesteads and other areas. The oldest colonies may consist of *Wisteria sinensis* or *Wisteria floribunda* and little else since the wisteria slowly overtops and kills all other plants It has the potential to occur in most southeastern states.

Environmental Description: This type at ARPO was characterized by sites where homes were purchased and demolished for inclusion in the park.

Vegetation Description:

Most Abundant Species: A wide variety of early successional and non-native trees and shrubs shared dominance within this type (Figure 13). Important species recorded at observation points, in addition to Chinese privet (*Ligustrum sinense*) and Wisteria (*Wisteria sinensis*), included shortleaf pine (*Pinus echinata*), sweetgum (*Liquidambar styraciflua*), black cherry (*Prunus serotina*), silktree (*Albizia julibrissin*), honeylocust (*Gleditsia triacanthos*), black locust (*Robinia pseudoacacia*), sycamore (*Platanthus occidentalis*), sacred bamboo (*Nandina domestica*), boxelder (*Acer negundo*), and sugarberry (*Celtis laevigata*). In some places native oak and hickory species were also important (*Quercus* spp., *Carya* spp.). Unlike more natural sites, many areas were heavily dominated by a single species such as Chinese privet, sweetgum, or black cherry.

Mapped Type Name: Ouachita Novaculite Glade
Macrogroup: Central Interior & Piedmont Acidic Scrub & Grassland
Group: Central Interior Acidic open Gland & Barrens
Association: *Quercus marilandica* var. *ashei* / *Schizachyrium scoparium* - *Andropogon gerardii* - *Monarda fistulosa* var. *stipitatoglandulosa* - *Streptanthus maculatus* / Lichens Novaculite Glade Wooded Herbaceous Vegetation
Type Common Name: Ashe's Blackjack Oak / Little Bluestem – Big Bluestem – Ouachita Beebalm – Clasping Jewelflower / Lichens Novaculite Glade Wooded Herbaceous Vegetation
Type Scientific Name: *Quercus marilandica* var. *ashei* / *Schizachyrium scoparium* - *Andropogon gerardii* - *Monarda fistulosa* var. *stipitatoglandulosa* - *Streptanthus maculatus* / Lichens Novaculite Glade Wooded Herbaceous Vegetation

Figure 14. The Ouachita Novaculite Glade type was a unique, non-forested type with a limited distribution at HOSP.

Global Summary: This association occurred in the novaculite uplift section of the central Ouachita Mountains in Arkansas and probably ranges into Oklahoma. It is found on ridgetops and south-facing sideslopes over fractured outcrops of novaculite, a hard, siliceous rock. This community is a xeric,

open habitat characterized by sparse tree cover of dwarfed (1-3 m) *Quercus marilandica var. ashei*, which can sometimes occur in clumps. Herbaceous cover is 100% except where bare rock is exposed or on talus. Lichens cover 40-70% of the exposed rock surface. Other occasional trees include *Acer barbatum, Carya texana, Pinus echinata, Prunus mexicana, Quercus muehlenbergii, Quercus rubra, Quercus stellata, Quercus velutina*, and *Ulmus alata*. Shrub cover is typically sparse, but may be locally dense and can include *Prunus mexicana, Rhus aromatica, Celtis tenuifolia, Frangula caroliniana, Ptelea trifoliata, Ribes curvatum, Rubus* sp., and *Sideroxylon lanuginosum (= Bumelia lanuginosa)*. The dominant grasses are *Schizachyrium scoparium, Andropogon gerardii, Danthonia spicata, Muhlenbergia sobolifera*, and *Dichanthelium linearifolium*. Forbs are abundant. These glade openings can range in size from small (less than one hectare) to larger, often linear formations covering as much as 40 hectares. In places it is a small-patch community occurring on ridgetops within the *Quercus rubra / Ostrya virginiana / Ptelea trifoliata - Ribes curvatum / Helianthus divaricatus* Woodland (CEGL007828). In other areas it is a large-patch community on south-facing slopes forming a mosaic with xeric woodland communities.

Environmental Description: This type usually occurs on narrow ridges or upper side slopes at HOSP. Occurrences are often liner and correspond with areas of shallow soil and exposed novaculite rock.

Vegetation Description: Open woodlands and herbaceous-dominated patches with scattered individual small trees and shrubs characterized this type (Figure 14). Common woody species included black hickory (*Carya texana*), post oak (*Quercus stellata*), and blackjack oak (*Quercus marilandica*). Important species in the shrub layer included dwarf hackberry (*Celtis tenuifolilia*) and winged elm (*Ulmus alata*). Little bluestem (*Schizachyrium scoparium*) was the most common and most important herbaceous species, and slimleaf panicgrass (*Dichanthelium linearifolium*) was also important.

Most Abundant Species:

Table 5. Species that occurred with relative cover >0.5% in one plot, or in 2 or more of 4 total plots representing Ouachita Novaculite Glade.

Scientific Name	Common Name	%Frequency	% Relative Cover
Tree Layer			
Carya texana	black hickory	100	14.6
Pinus echinata	shortleaf pine	50	8.2
Prunus serotina	black cherry	50	0.7
Pyrus calleryana	Callery pear	25	1.0
Quercus marilandica	blackjack oak	75	3.5
Quercus stellata	post oak	100	2.7
Quercus velutina	black oak	25	1.0
Sideroxylon lanuginosum	gum bully	25	1.0
Shrub Layer			

Scientific Name	Common Name	%Frequency	% Relative Cover
Celtis tenuifolia	dwarf hackberry	75	11.3
Rhus copallinum	winged sumac	50	0.5
Rubus flagellaris	northern dewberry	75	5.3
Ulmus alata	winged elm	50	9.5
Vaccinium arboreum	farkleberry	50	4.7
Vaccinium stamineum	upland highbush blueberry	50	1.8
Viburnum rufidulum	rusty blackhaw	25	1.0
Herbaceous Layer & Vines			
Acalypha gracilens	slender threeseed mercury	75	0.5
Ambrosia artemisiifolia	annual ragweed	50	0.5
Andropogon gerardii	big bluestem	50	1.8
Carex umbellata	parasol sedge	50	3.0
Chaerophyllum tainturieri	hairyfruit chervil	50	0.5
Danthonia spicata	poverty oatgrass	50	1.8
Dichanthelium linearifolium	slimleaf panicgrass	75	5.3
Elymus virginicus	Virginia wildrye	50	1.8
Erigeron annuus	eastern daisy fleabane	50	0.5
Euphorbia corollata	flowering spurge	50	0.5
Galactia volubilis	downy milkpea	50	1.8
Gamochaeta purpurea	spoonleaf purple everlasting	50	0.5
Helianthus hirsutus	hairy sunflower	75	0.5
Lactuca canadensis	Canada lettuce	50	0.5
Lespedeza stuevei	tall lespedeza	50	0.5
Oxalis stricta	common yellow oxalis	50	0.5
Schizachyrium scoparium	little bluestem	100	4.1
Scutellaria ovata	heartleaf skullcap	50	1.8
Smilax bona-nox	saw greenbriar	50	1.8
Solidago hispida	hairy goldenrod	50	0.5
Sphenopholis obtusata	prairie wedgescale	50	0.5
Sporobolus clandestinus	rough dropseed	50	0.5
Triodanis perfoliata	clasping Venus' looking-glass	50	0.5

Mapped Type Name: Ouachita-Ozark Small Stream Hardwood Forest
Macrogroup: Southern Coastal Plain Floodplain Forest
Group: Oak – Sweetgum Floodplain Forest
Association: *Liquidambar styraciflua* - (*Quercus alba*, *Acer saccharum* / *Carpinus caroliniana* / *Lindera benzoin* Forest
Type Common Name: Sweetgum – (White Oak, Sugar Maple) / American Hornbeam / Northern Spicebush Forest
Type Scientific Name: *Liquidambar styraciflua* - (*Quercus alba*, *Acer saccharum* / *Carpinus caroliniana* / *Lindera benzoin* Forest

Figure 15. The Ouachita-Ozark Small Stream Hardwood Forest type occupied narrow valley bottoms throughout HOSP.

Global Summary: This community includes hardwood forests associated with small or intermittent streams in the Ouachita Mountains and Ozarks of Arkansas and Oklahoma. These forests develop on small alluvial flats, terraces, and levees, often on or adjacent to cobble bars. In contrast to forests found on larger rivers (broader floodplains) in the region, vegetation zonation in this community is absent or poorly defined. Examples of this community may have ambiguous hydrology and are often

described as being on the conceptual border between upland and temporarily flooded, a fact reflected in the species composition. Canopy composition is variable from site to site but always includes *Liquidambar styraciflua*, often as the main canopy dominant. Other species that may have high coverage in the canopy are *Quercus alba, Acer saccharum, Fagus grandifolia, Fraxinus americana, Fraxinus pennsylvanica*, and *Tilia americana var. caroliniana*. Other typical canopy associates are *Betula nigra, Juglans nigra, Platanus occidentalis, Carya cordiformis, Celtis laevigata, Nyssa sylvatica, Quercus nigra, Quercus rubra*, and *Ulmus americana*. *Carpinus caroliniana* is a typical subcanopy dominant, which can also include *Ostrya virginiana, Magnolia acuminata, Cercis canadensis*, and *Acer negundo*. The shrub layer varies in density and composition from site to site. Characteristic shrubs are *Lindera benzoin, Arundinaria gigantea, Alnus serrulata, Callicarpa americana, Dirca palustris*, and *Hypericum prolificum*. *Toxicodendron radicans* and *Parthenocissus quinquefolia* are common vines. The herbaceous strata can be species-rich on some sites, but other examples have sparse, species-poor herb layers. Typical species include *Boehmeria cylindrica, Brachyelytrum erectum, Carex* sp., *Chasmanthium latifolium, Dioscorea oppositifolia, Iris cristata, Pedicularis canadensis, Polygonum virginianum*, and *Verbesina alternifolia*.

Environmental Description: This type occupied narrow valley bottoms throughout HOSP, and also occurred on the floodplains of larger streams. Soils were more or less well-developed and the hydrologic regime was generally flashy along mainly higher-gradient, small streams.

Vegetation Description: White oak (*Quercus alba*) and sweet gum (*Liquidambar styraciflua*) were the most frequent and most dominant overstory trees within this type, and shortleaf pine (*Pinus echinata*) was also often important (Figure 15). Flowering dogwood (*Cornus florida*), American hornbeam (*Carpinus caroliniana*), and hophornbeam (*Ostrya virginiana*) were important understory trees. Eastern poison ivy (*Toxicodendron radicans*) was found in all plots, and saw greenbriar (*Smilax bona-nox*) in nine out of ten plots.

Most Abundant Species:

Table 6. Relative cover and frequency for species within the Ouachita-Ozark Small Stream Hardwood Forest. Species in at least 4 of 10 plots with an average relative cover of >=2.0% where they occurred are included.

Scientific Name	Common Name	%Frequency	% Relative Cover
Tree Layer			
Acer rubrum	red maple	60	6.6
Carpinus caroliniana	American hornbeam	60	18.2
Carya alba	mockernut hickory	80	6.3
Celtis occidentalis	common hackberry	40	12.8
Cornus florida	flowering dogwood	90	5.7
Fraxinus americana	white ash	40	4.8
Liquidambar styraciflua	sweetgum	100	30.6
Nyssa sylvatica	blackgum	70	14.7

Scientific Name	Common Name	%Frequency	% Relative Cover
Ostrya virginiana	hophornbeam	70	27.2
Pinus echinata	shortleaf pine	60	32.5
Prunus serotina	black cherry	70	8.9
Quercus alba	white oak	100	20.7
Quercus rubra	northern red oak	70	2.7
Ulmus alata	winged elm	80	14.3
Shrub Layer			
Ligustrum sinense	Chinese privet	50	9.6
Symphoricarpos orbiculatus	coralberry	40	4.1
Vaccinium pallidum	blue ridge blueberry	50	7.3
Herbaceous Layer & Vines			
Ipomoea pandurata	man of the earth	40	4.8
Lonicera japonica	Japanese honeysuckle	70	7.9
Parthenocissus quinquefolia	Virginia creeper	70	7.1
Smilax bona-nox	saw greenbriar	90	4.7
Toxicodendron radicans	eastern poison ivy	100	4.6
Vitis rotundifolia var. rotundifolia	muscadine	80	2.9

Mapped Type Name: Ozark-Ouachita Dry-Mesic White Oak – Black Oak – Hickory Forest
Macrogroup: Southern & South-Central Oak – Hickory – Pine - Forest
Group: South-Central Interior Oak Forest & Woodland
Association: *Quercus alba* - *Quercus velutina* - *Carya alba* / *Desmodium nudiflorum* Ozark Forest
Type Common Name: White Oak – Black Oak – Mockernut Hickory / Naked-flower Tick-trefoil Ozark Forest
Type Scientific Name: Quercus alba - Quercus velutina - Carya alba / Desmodium nudiflorum Ozark Forest

Figure 16. The Ozark-Ouachita Dry-Mesic White Oak – Black Oak – Hickory Forest occupied mesic north and east facing slopes at HOSP.

Global Summary: This dry-mesic white oak - hickory forest is found in the Ozark and Ouachita ecoregions of Arkansas and possibly Oklahoma and Missouri. Stands occur in dissected landscapes at moderate elevations (200-550 m [600-1800 feet]), on mid to higher slopes of various aspects, as well as toeslopes of gently convex form. Examples on different aspects vary somewhat in expression; however, the canopy is typically dominated by *Quercus alba, Quercus velutina*, and *Carya alba*. *Carya glabra* is common and *Quercus rubra* may be found in some examples, particularly on north- and east-facing slopes. The subcanopy may also contain *Acer rubrum, Acer saccharum, Amelanchier arborea*, and *Nyssa sylvatica*. *Acer rubrum, Cornus florida, Ostrya virginiana*,

and *Vaccinium stamineum* may be prominent low shrubs. The herb layer composition may be quite variable depending on aspect, but it is typically dominated by *Amphicarpaea bracteata, Desmodium glutinosum, Desmodium nudiflorum, Dichanthelium boscii, Monarda bradburiana, Parthenocissus quinquefolia*, and/or *Toxicodendron radicans*.

Environmental Description: This type occupied mesic north and east-facing slopes at HOSP. The type also occurred in some lower landscape positions on flats or very gentle slopes.

Vegetation Description: The primary dominant overstory tree of this type was white oak (*Quercus alba*). Other important species in the overstory included mockernut hickory (*Carya alba*), black hickory (*Carya texana*), blackgum (*Nyssa sylvatica*), and black cherry (*Prunus serotina*)(Figure 16). Northern red oak (*Quercus rubra*) was also important in most plots. Important understory trees included flowering dogwood (*Cornus florida*) and winged elm (*Ulmus alata*). Eastern poison ivy (*Toxicodendron radicans*) was found in 18 of 20 plots sampled.

Most Abundant Species:

Table 7. Relative cover and frequency for species within the Ozark-Ouachita Dry-Mesic White Oak – Black Oak – Hickory Forest. Species in at least 3 of 20 plots with an average relative cover of >1.0% are included.

Scientific Name	Common Name	%Frequency	% Relative Cover
Tree Layer			
Acer rubrum	red maple	40	7.1
Carya alba	mockernut hickory	100	12.9
Carya texana	black hickory	100	12.4
Cornus florida	flowering dogwood	95	10.0
Nyssa sylvatica	blackgum	95	17.0
Pinus echinata	shortleaf pine	65	9.5
Prunus serotina	black cherry	100	14.2
Quercus alba	white oak	100	32.4
Quercus rubra	northern red oak	75	18.0
Quercus velutina	black oak	100	7.0
Ulmus alata	winged elm	35	3.7
Shrub Layer			
Amelanchier arborea	common serviceberry	80	3.2
Frangula caroliniana	carolina buckthorn	40	16.4
Vaccinium arboreum	farkleberry	40	1.6
Vaccinium pallidum	blue ridge blueberry	90	7.1
Vaccinium stamineum	upland highbush blueberry	65	2.0
Herbaceous Layer & Vines			
Toxicodendron radicans	eastern poison ivy	90	4.1
Vitis aestivalis	summer grape	70	3.1
Vitis rotundifolia var. *rotundifolia*	muscadine	85	3.0

Mapped Type Name: Ozark/Ouachita Post Oak – Blackjack Oak / Little Bluestem Woodland
Macrogroup: Southern & South-Central Oak – Hickory – Pine Forest
Group: South-Central Interior Oak Forest & Woodland
Association: *Quercus stellata* - *Quercus marilandica* - *Quercus velutina* - *Carya texana* / *Schizachyrium scoparium* Woodland
Type Common Name: Post Oak – Blackjack Oak – Black Oak – Black Hickory / Little Bluestem Woodland
Type Scientific Name: *Quercus stellata* - *Quercus marilandica* - *Quercus velutina* - *Carya texana* / *Schizachyrium scoparium* Woodland

Figure 17. The Ozark/Ouachita Post Oak – Blackjack Oak / Little Bluestem Woodland was found on ridge tops and upper slopes at HOSP.

Global Summary: This post oak - blackjack oak woodland type occurs in the central United States, particularly in the Interior Low Plateau and Interior Highlands region. Stands occur on gentle to steep hills and plains, bluff escarpments, and broad ridges and flats with any aspect, but primarily south- and west-facing slopes. Soils are rapidly to very rapidly drained, shallow, and strewn with boulders, cobbles, gravel, and sand. Soil pH is neutral to slightly acidic. Bedrock can be sandstone, chert, or igneous rock and is often exposed. The tree canopy is short to medium (7-20 m), spreading, open,

and limby. Dominant species include *Quercus stellata* and/or *Quercus marilandica*. Other species may form a minor canopy component, scattered in the canopy, and include (e.g., *Quercus velutina, Quercus rubra, Quercus alba*, and *Carya alba*). The understory is very poorly developed, consisting of a few widely scattered shrubs and small trees, including, in addition to the dominant trees, *Ulmus alata* and *Vaccinium* spp. (*Vaccinium arboreum, Vaccinium stamineum*, or *Vaccinium pallidum*). Coverage of the herbaceous stratum can vary from quite sparse to moderately dense, consisting of mixed grasses and forbs. Typical species include *Helianthus divaricatus, Porteranthus stipulatus, Danthonia spicata, Schizachyrium scoparium, Cunila origanoides, Andropogon gerardii*, and *Liatris aspera*, but others may occur. Lichens and mosses can be abundant.

Environmental Description: This type was found on well-drained ridge tops and upper slopes at HOSP. The communities usually formed narrow; linear strips from 50 to 100 meters wide.

Vegetation Description: Black hickory (*Carya texana*) was the prevailing overstory dominant of this type, and blackjack oak (*Quercus marilandica*), post oak (*Quercus stellata*), and black cherry (*Prunus serotina*) were also important trees (Figure 17). Winged elm (*Ulmus alata*) and eastern redcedar (*Juniperus virginiana*) were important small trees. Slimleaf panicgrass (*Dichanthelium linearifolium*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and heartleaf scullcap (*Scutellaria ovata*) were important herbaceous components of this generally open woodland.

Most Abundant Species:

Table 8. Relative cover and frequency for species within the Ozark/Ouachita Post Oak – Blackjack Oak / Little Bluestem Woodland. Species that occurred within at least one plot with >=15% cover, or in at least 2 plots with >2.0% cover, are included.

Scientific Name	Common Name	%Frequency	% Relative Cover
Tree Layer			
Carya texana	black hickory	100	32.4
Juniperus virginiana	eastern redcedar	40	2.0
Prunus serotina	black cherry	100	5.3
Quercus marilandica	blackjack oak	80	22.0
Quercus stellata	post oak	80	23.4
Ulmus alata	winged elm	20	28.1
Shrub Layer			
Amelanchier arborea	common serviceberry	60	0.5
Rhus aromatica	fragrant sumac	40	2.0
Vaccinium arboreum	farkleberry	40	14.1
Herbaceous Layer & Vines			
Andropogon gerardii	big bluestem	80	1.1
Carex muehlenbergii	Muhlenberg's sedge	20	15.0
Carex umbellata	parasol sedge	60	0.5
Clitoria mariana	Atlantic pigeonwings	60	0.5

Scientific Name	Common Name	%Frequency	% Relative Cover
Coreopsis grandiflora	largeflower tickseed	60	0.5
Danthonia spicata	poverty oatgrass	60	0.5
Dichanthelium linearifolium	slimleaf panicgrass	100	1.0
Galactia volubilis	downy milkpea	60	0.5
Helianthus hirsutus	hairy sunflower	80	0.5
Oxalis violacea	violet woodsorrel	80	0.5
Piptochaetium avenaceum	blackseed speargrass	40	9.0
Rubus flagellaris	northern dewberry	60	0.5
Schizachyrium scoparium	little bluestem	60	5.3
Scutellaria ovata	heartleaf scullcap	80	1.8
Symphyotrichum anomalum	manyray aster	60	0.5
Symphyotrichum patens	late purple aster	60	0.5
Tradescantia hirsutiflora	hairyflower spiderwort	80	0.5
Triodanis perfoliata	clasping Venus' looking-glass	80	0.5

Mapped Type Name: Ozark/Ouachita Shortleaf Pine – Oak Dry Woodland
Macrogroup: Southern & South-Central Oak – Hickory – Pine Forest
Group: Shortleaf Pine – Oak Forest
Association: *Pinus echinata* - *Quercus stellata* - *Quercus marilandica* / *Schizachyrium scoparium* Woodland
Type Common Name: Shortleaf Pine – Post Oak – Blackjack Oak / Little Bluestem Woodland
Type Scientific Name: *Pinus echinata* - *Quercus stellata* - *Quercus marilandica* / *Schizachyrium scoparium* Woodland

Figure 18. The Ozark/Ouachita Shortleaf Pine – Oak Dry Woodland was found on ridge tops and on dry south and west facing slopes at HOSP.

Global Summary: This shortleaf pine - oak woodland is found in the Ozark/Ouachita region of the United States. Stands occur along ridges and on upper south- to southwest-facing slopes. The vegetation contains an open canopy dominated by *Pinus echinata* codominating with *Quercus stellata* and *Quercus marilandica*, either singly or in combination. *Pinus echinata* may form an emergent canopy over the oaks. Common woody associates include *Carya texana, Quercus velutina*, and *Diospyros virginiana*. Grassy openings are dominated by *Schizachyrium scoparium*. Other abundant herbs include *Baptisia bracteata, Helianthus hirsutus, Liatris aspera, Solidago nemoralis,*

Solidago petiolaris, and *Tephrosia virginiana*. This type represents the driest shortleaf pine - oak communities in the Ozarks.

Environmental Description: This type occurred on dry south and west facing slopes and on ridge tops at HOSP. Some broader, well-drained uplands on gentle slopes also supported this community.

Vegetation Description: Shortleaf pine (*Pinus echinata*) was the prevailing dominant of this type, with blackjack oak (*Quercus marilandica*), black hickory (*Carya texana*), and post oak (*Quercus stellata*) also important (Figure 18). Winged elm (*Ulmus alata*) was an important small tree, and farkleberry (*Vaccinium arboretum*) an important shrub. Little bluestem (*Schizachyrium scoparium*) and slimleaf panicgrass (*Dichanthelium linearifolium*) were the most important herbaceous species.

Most Abundant Species:

Table 9. Relative cover and frequency for species within the Ozark/Ouachita Shortleaf Pine – Oak Dry Woodland. Species in at least 3 plots with cover >1%, or in 5 or more plots, are included.

Scientific Name	Common Name	%Frequency	% Relative Cover
Tree Layer			
Carya texana	black hickory	83.3	14.4
Pinus echinata	shortleaf pine	100.0	37.4
Prunus serotina	black cherry	91.7	3.7
Quercus marilandica	blackjack oak	100.0	17.6
Quercus stellata	post oak	75.0	16.6
Ulmus alata	winged elm	58.3	0.7
Shrub Layer			
Vaccinium arboreum	farkleberry	91.7	13.3
Vaccinium pallidum	blue ridge blueberry	33.3	4.8
Vaccinium stamineum	upland highbush blueberry	33.3	0.5
Herbaceous Layer & Vines			
Antennaria plantaginifolia	woman's tobacco	33.3	1.1
Baptisia bracteata	longbract wild indigo	41.7	0.5
Carex umbellata	parasol sedge	41.7	0.5
Danthonia spicata	poverty oatgrass	25	1.3
Dichanthelium dichotomum	cypress panicgrass	41.7	0.5
Dichanthelium linearifolium	slimleaf panicgrass	91.7	1.0
Oxalis violacea	violet woodsorrel	41.7	0.5
Rubus flagellaris	northern dewberry	50.0	0.9
Schizachyrium scoparium	little bluestem	83.3	2.5
Scutellaria ovata	heartleaf skullcap	25	1.3
Smilax bona-nox	saw greenbriar	66.7	3.0
Solidago buckleyi	Buckley's goldenrod	41.7	0.5
Toxicodendron radicans	eastern poison ivy	25	1.3
Vitis rotundifolia var. rotundifolia	muscadine	58.3	7.9

Mapped Type Name: Shortleaf Pine – Oak Dry-Mesic Woodland
Macrogroup: Southern & South-Central Oak – Hickory – Pine Forest
Group: Shortleaf Pine – Oak Forest
Association: *Pinus echinata – Quercus alba* / *Schizachyrium scoparium* Woodland
Type Common Name: Shortleaf Pine –White Oak / Little Bluestem Woodland
Type Scientific Name: *Pinus echinata – Quercus alba* / *Schizachyrium scoparium* Woodland

Figure 19. Shortleaf Pine – Oak Dry-Mesic Woodland was found on mesic north and east facing slopes at HOSP.

Global Summary: This shortleaf pine - oak woodland type is found in the central United States, in the Ozarks and Ouachita Mountains of Missouri and Arkansas, likely extending into Oklahoma. Stands occur on upper to middle, south-facing slopes, saddles, and flatter ridgelines. Soils are shallow to deep (25-100 cm), and well-drained. Parent material is a variety of sandstone and mixed sandstone/shale-derived substrates or, in parts of the Missouri Ozarks and central Ouachitas, chert substrates. The vegetation contains an open canopy. The canopy is dominated by *Pinus echinata* codominating with *Quercus alba, Quercus rubra*, or *Quercus velutina*, either singly or in combination. *Pinus echinata* often forms an emergent canopy over the oaks. Other woody species

may be present in the shrub and sapling strata. Species from examples in the central Ouachita Mountains include *Acer rubrum, Amelanchier arborea, Carya alba, Castanea pumila var. ozarkensis (= Castanea ozarkensis), Cornus florida, Hamamelis virginiana, Nyssa sylvatica, Ostrya virginiana, Prunus serotina, Sassafras albidum, Toxicodendron radicans, Vaccinium arboreum, Vaccinium stamineum*, and *Vitis rotundifolia*. Cover of the herbaceous stratum is variable (20-50%) depending on crown closure and fire history and comprises a mixture of graminoid and forb species. The herbaceous layer is often dominated by *Schizachyrium scoparium* and *Dichanthelium linearifolium*, but a diversity of herbaceous species is present. Other herbaceous species can include *Antennaria plantaginifolia, Symphyotrichum anomalum (= Aster anomalus), Baptisia bracteata var. leucophaea, Carex* sp., *Clitoria mariana, Cunila origanoides, Danthonia spicata, Desmodium marilandicum, Desmodium glutinosum, Lespedeza capitata, Lespedeza virginica, Dichanthelium latifolium, Dichanthelium sphaerocarpon var. isophyllum, Solidago caesia, Solidago petiolaris*, and *Solidago ulmifolia*.

Environmental Description: This type was found on mesic north and east facing slopes at HOSP. Some low flats and gentle slopes also supported this community.

Vegetation Description: Shortleaf pine (*Pinus echinata*) was the prevailing dominant of this type, and white oak (*Quercus alba*) was the second most important canopy tree species (Figure 19). Black oak (*Quercus velutina*), blackgum (*Nyssa sylvatica*), and black hickory (*Carya texana*) were frequently important. Flowering dogwood (*Cornus florida*) was an important small tree. Blue ridge blueberry (*Vaccinium pallidum*) and upland highbush blueberry (*Vaccinium stamineum*) were frequent understory shrubs. Saw greenbriar (Smilax bona-nox) and muscadine (*Vitis rotundifolia* var. *rotundifolia*) were frequently encountered vines.

Most Abundant Species:

Table 10. Relative cover and frequency for species within the Shortleaf Pine – Oak Dry-Mesic Woodland. Species in at least 6 plots with >=1% relative cover, or in at least 11 plots, are included.

Scientific Name	Common Name	%Frequency	% Cover
Tree Layer			
Acer rubrum	red maple	72.7	4.3
Carya alba	mockernut hickory	54.5	2.9
Carya texana	black hickory	95.5	5.9
Cornus florida	flowering dogwood	72.7	9.2
Liquidambar styraciflua	sweetgum	40.9	1.2
Nyssa sylvatica	blackgum	86.4	17.0
Pinus echinata	shortleaf pine	100.0	40.9
Prunus serotina	black cherry	81.8	5.3
Quercus alba	white oak	95.5	26.4
Quercus rubra	northern red oak	68.2	7.8
Quercus stellata	post oak	36.4	4.9

Quercus velutina	black oak	90.9	8.7
Ulmus alata	winged elm	27.3	3.1
Shrub Layer			
Amelanchier arborea	common serviceberry	68.2	2.5
Sassafras albidum	sassafras	31.8	1.0
Vaccinium arboreum	farkleberry	54.5	5.9
Vaccinium pallidum	blue ridge blueberry	95.5	13.6
Vaccinium stamineum	upland highbush blueberry	72.7	2.6
Herbaceous Layer & Vines			
Pteridium aquilinum	western brackenfern	54.5	1.9
Smilax bona-nox	saw greenbriar	81.8	0.6
Toxicodendron radicans	eastern poison ivy	50.0	0.8
Vitis rotundifolia var. *rotundifolia*	muscadine	86.4	3.5

Discussion

Our analyses of species distributions and communities were generally in line with the findings of Dale and Ware (1999). Communities at HOSP fit within definitions and descriptions of types found throughout the Ouachita and Ozark ecoregions. Shortleaf pine (*Pinus echinata*) distribution was not closely related to abiotic variables, and this species was dominant or co-dominant across 56.0% of the park, exclusive of water and cultural areas. Species that were more abundant on more mesic slopes included white oak (*Quercus alba*), northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), mockernut hickory (*Carya tomentosa*). Species more common on drier sites included post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), and black hickory (*Carya texana*).

Environmental gradients were fairly steep at HOSP, and corresponded with slope exposure and land position. However, abiotic variables often did not change in an abrupt fashion across very short distances, as would be the case with boundaries in geologic strata or soils. Thus, although boundaries between types were drawn as abrupt lines, parts of the landscape were intermediate in species composition between types. This was especially true for the Ozark-Ouachita Small Stream Hardwood Forest, which was often distributed within narrow valleys and small stream bottoms where bottomland species were important, but shortleaf pine was still a significant component. The importance of shortleaf pine within these types was presumably at least in part due to past disturbances, since pines are often planted, favored via management (e.g. seed trees left after harvesting), or naturally recruit into openings after timber harvesting.

The Ouachita Novaculite Glade type was the smallest community at HOSP, but one of the more rare and unique types within the ecoregion. Herbaceous species diversity was relatively high, and tree and shrub canopy low. Several species reached their maximum importance in this type, including dwarf hackberry (*Celtis tenuifolia*), hairy sunflower (*Helianthus hirsutus*), big bluestem (*Andropogon gerardii*), and parasol sedge (*Carex umbellata*).

Field Survey

The topography of HOSP was deceptively challenging, and walking to plots down or up steep slopes was time-consuming. Distribution of new field plots in the future should be done with this in mind. Documentation of dynamics and response to management within all communities via repeated quantitative sampling at HOSP will be highly desirable

NVC Classification

The composition of most of the communities at HOSP corresponded to well-known and well-documented oak and pine-oak types endemic to the region. Data collected at HOSP will serve to reinforce existing descriptions of these types. The Ouachita-Ozark Small Stream Hardwood Forest type at HOSP had more shortleaf pine than most examples of this type, probably at least in part due to past management practices. The Disturbance Woodland and Forest type was a result of recovery of vegetation after demolition of old home sites. These areas are quite diverse in composition, and do not represent a type that will likely ever be recognized by the NVC.

Digital Imagery and Interpretation
Multiple years of ortho-imagery were available for the park and were used to develop map polygons via heads-up digitizing. In addition, photos available on-line were viewed, and seemed to be of high quality. Workers in the future may find on-line air photos to be adequate for many purposes. Because the park was not too large, heads up digitizing of polygons that represent the classified types was possible.

Accuracy Assessment
Several difficulties in AA and mapping resulted in an overall map accuracy of 79.1%. This seemed acceptable for HOSP, since the alternative would be to map few types, which would result in a less useful product overall.

Recognized community types at HOSP were different in composition when frequency and cover values were averaged across multiple samples, as revealed by the classification results and summary data tables. However, differences in composition were relatively subtle, which made the development and implementation of keys difficult. Proper assignment of AA points to a type via the key, using relative cover estimates, was tentative for many plots.

Composition differences among types were related mainly to abiotic variables, particularly soil moisture as it is controlled by slope exposure and land position. Fine-scale differences in land shape, and presumably soil moisture, on steep slopes was apparent. For example, concave areas upslope from head drainages were apparently wetter than adjunct convex side slopes. This caused small inclusions of dry-mesic types within dry types, and visa-versa. Also, narrow stream floodplains had canopy from adjunct uplands extending into the community from trees rooted outside of an AA plot on occasion. Some of the stream valleys were heavily dominated by pines, and this made assignment of plots by workers to the Ouachita-Ozark Small Stream Hardwood Forest type less likely than it should have been, since the key relied on workers to recognize low levels of relative cover by moist-soil deciduous species.

Future Recommendations
Management efforts directed at restoration and maintenance of the small Ouachita Novaculite Glade communities at HOSP were evident at the time of sampling. Active management and repeated sampling of this type over time to document response to management would be desired. In addition, an area of old-growth pine was inventoried by Witsell (2003), and future re-sampling of this site would be desirable.

Non-native and weedy woody species, particularly Chinese privet (*Ligustrum sinense*), Chinese wisteria (*Wisteria sinensis*), silktree (*Albizia julibrissin*), honeylocust (*Gleditsia triacanthos*), black locust (*Robinia pseudoacacia*), and sacred bamboo (*Nandina domestica*) were present around old home site demolitions and in patches throughout the park. Among these, Chinese privet was most abundant and sacred bamboo the most common woody species found on exotic species monitoring transects (Short et al. 2010). Japanese honeysuckle (*Lonicera japonica*) was a common non-native vine. Management of these species at HOSP represents a challenge for the future.

Research Opportunities

Many of the forests and woodlands at HOSP are fairly mature, and some have been documented as old-growth (Witsell 2003). In addition, the Ouachita Novaculite Glade community is unique, of limited distribution at HOSP, and uncommon or rare throughout the region. Documentation of the dynamics of these communities over time in response to management (e.g. prescribed fire, see National Park Service 2014) represents a significant research opportunity. Documentation of management actions taken to reduce the abundance of non-native species also represents a research opportunity. Finally, the future of areas where homes were removed is of concern, although the focus may best be first on preventing the spread of non-native and invasive species from these areas into more natural adjacent woodlands and forests. Restoration of these areas may be fraught with difficulty, and efforts spent along these lines might represent great effort with little reward in terms of successful restorations.

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Appendix A: Contingency Table for Vegetation Mapping of Hot Springs National Park

		Reference Data (Accuracy Assessment Field Data)							User's Error			
	Map Units	Disturbance Woodland and Forest	Ouachita-Ozark Small Stream Hardwood Forest	Ouachita Novaculite Glade	Ozark-Ouachita Dry-Mesic - White Oak - Black Oak - Hickory Forest	Ozark/Ouachita Post Oak - Blackjack Oak / Little Bluestem Woodland	Ozark/Ouachita Shortleaf Pine - Oak Dry Woodland	Shortleaf Pine - Oak Dry-Mesic Woodland	Totals	Commission Accuracy	90% Conf. Interval	
											-	+
Sample Data (Polygon Map Data)	Disturbance Woodland and Forest	**9**					1		10	90.0%	69.4%	100.0%
	Ouachita-Ozark Small Stream Hardwood Forest		**11**		1		2	3	17	64.7%	42.7%	86.7%
	Ouachita Novaculite Glade			**4**		1			5	80.0%	40.6%	100.0%
	Ozark-Ouachita Dry-Mesic - White Oak - Black Oak - Hickory Forest			1	**24**				25	96.0%	87.6%	100.0%
	Ozark/Ouachita Post Oak - Blackjack Oak / Little Bluestem Woodland				5	**21**	1		27	77.8%	62.8%	92.8%
	Ozark/Ouachita Shortleaf Pine - Oak Dry Woodland					3	**16**	7	26	61.5%	43.9%	79.2%
	Shortleaf Pine - Oak Dry-Mesic Woodland				1		1	**25**	27	92.6%	82.4%	100.0%
	Totals	9	11	5	31	25	21	35				
Producer's Error	Omission Accuracy	100.0%	100.0%	21.7%	72.5%	72.9%	73.9%	77.7%	**110 Total Correct Points**			
	90% Conf. -	99.8%	96.3%	21.5%	71.4%	71.5%	70.2%	74.4%	**137 Total Points**			
	Level +	100.0%	100.0%	21.9%	73.6%	74.3%	77.6%	81.0%				
Overall Total Accuracy =79.1% Overall Kappa Index =76.2% Overall 90% Upper and Lower Confidence Interval =72.8% and 85.4%												

Accuracy Assessment Contingency Table:
The contingency table combines the sample contingency and population contingency tables in which rows represent the map classes from the vegetation map and columns are the map classes determined in the field. The shaded areas display the number of accuracy assessment points where the field determination of the map class agrees with the vegetation map. Disagreement between field data (columns) and map data result in producer's error (omission error). Conversely, disagreement between map data (rows) and field data reflect user's error (errors of commission). Both types of error are reported in terms of accuracy (100% indicates no errors) and a corresponding 90% confidence interval. The total number of correct points out of the total number of accuracy assessment points (shaded diagonal values) provides the degree to which map classes were interpreted correctly. The Kappa Index is an index that accounts for chance agreement in the contingency table.

Appendix B: Example of Plot Survey Form

NPS VEGETATION MAPPING PROGRAM – PLOT SURVEY FORM

PLOT LOCATION AND DESCRIPTION

Plot Code _____ Surveyors _____
Date _____

Plot Directions

_____

Plot Dimensions _____ by _____ m Photos (y/n) _____
Provisional Community Name

_____

Relative Stand Size extensive (>100x plot), large (>10-100x plot), small (3-10x plot), very small (1-3x plot), unknown
Representativeness

_____
_____
_____

Landform (circle) interfluve, gap/saddle, side slope, terrace/bench flat plain

Topographic Position (circle) crest, upper slope, middle slope, lower slope, toe slope, plain/level/bottom, basin/depression

Hydrologic Regime ___Upland ___Permanently flooded ___Semipermanently flooded ___Seasonally/Temporarily flooded ___Unknown

Plot Shape (circle) concave convex flat irregular
General Comments

_____
_____
_____

Plot Code _____

NPS VEGETATION MAPPING PROGRAM – PLOT SURVEY FORM

VEGETATION SAMPLING

Leaf Phenology	Leaf type	Physiognomic Class
____Deciduous (<25% evergreen)	____Broadleaf	____Forest
____Evergreen (<25% deciduous)	____Needleleaf	____Woodland
____Mixed deciduous/evergreen	____Mixed	____Sparse woodland
____Perennial graminoid	____Graminoid	____Shrubland
____Perennial forb	____Forb	____Sparse shrubland
____Perennial mixed	____Pteridophyte	____Herbaceous
____Annual herbaceous	____Non-vascular	____Sparse vegetation

Strata	%Cover (1=<1%, 2=1-5%, 3=5-25%, 4=25-50%, 5=50-75%, 6=75-95%, 7=95-100%)
T1 Emergent >30m	_____
T2 Tree Canopy 20-30m	_____
T3 Tree Subcanopy 5-20m	_____
S1 Tall Shrub 1-5m	_____
S2 Short Shrub <1m	_____
H Herbaceous	_____

SPECIES COMPOSITION AND COVER CLASS BY STRATUM
%Cover (1=<1%, 2=1-5%, 3=5-25%, 4=25-50%, 5=50-75%, 6=75-95%, 7=95-100%)

T1	T2	T3	S1	S2	H	Species	Comments

Plot Code __________

T1	T2	T3	S1	S2	H	Species	Comments

Appendix C: Hot Springs National Park Dichotomous Key to Mapped Current Vegetation Types

1a. Open, herbaceous-dominated community with tree canopy <30% .....

.....**Ouachita Novaculite Glade**

1b. Wooded community with tree canopy >30% **2**

2a. Community showing signs of heavy disturbance from past development, with non-native species such as privet, Japanese honeysuckle, Chinese wisteria, Nandina, silktree, and multiflora rose important together with natives such as shortleaf pine, black cherry, eastern redcedar, and boxelder .....D**isturbance Woodland and Forest**

2b. Community composed mainly of native species and not showing signs of heavy past disturbance or if so, occurring within a matrix of more natural vegetation **3**

3a. Combined relative cover within the canopy of sweetgum, common hackberry, black walnut, willow oak, American sycamore and ash species >9%; low landscape position along mainly perennial streams or on bottomland terraces .... **Ouachita-Ozark Small Stream Hardwood Forest**

3b. Combined relative cover different from the above combination of species; not on low landscape positions along mainly perennial stream or on bottomland terraces **4**

4a. Combined relative cover within the canopy of white oak, northern red oak, black oak, mockernut hickory, and blackgum <5% **5**

5a) Relative cover within the canopy of shortleaf pine >20% .... **Ozark/ Ouachita Shortleaf Pine - Oak Dry Woodland**

5b) Relative cover within the canopy of shortleaf pine <20% ..... **Ozark/ Ouachita Post Oak - Blackjack Oak / Little Bluestem Woodland**

4b) Combined relative cover within the canopy of the above species >5% **6**

6a. Relative cover within the canopy of shortleaf pine >20%. ....**Shortleaf Pine - Oak Dry-Mesic Woodland**

6b. Relative cover within the canopy of shortleaf pine <20% .....

.... **Ozark-Ouachita Dry-Mesic White Oak - Black Oak - Hickory Forest**

Appendix D: Example of Accuracy Assessment Form

Accuracy Assessment Form

NPS Vegetation Inventory

1. PLOT (WAYPOINT) #:_____ 2. DATE:_____

3. OBSERVER (DETERMING ASSOCIATION) _____

4. Observer (assisting) _____

5. ACCURACY OF NAVIGATION (METERS) _____

6. How Determined: _____

7. UTM EASTING: _____ 8. UTM: _____

9. UTM Zone: _____ 10. Datum: _____

11. If GPS Position is an intentional offset from the waypoint, circle the explanation:

a.) Mosaicing scenario (too heterogeneous to key because of two or more clearly distinct types within observation area)

b.) Physical constraints in reaching waypoint

c.) Other (explain as needed):_____

_____

_____

12. VEGETATION ASSOCIATION (Primary call): _____

_____

13. Other possible associations (complexing scenario) (if applicable): _____

_____

14. Explanation for # 13 (if applicable): _____

_____

Appendix E: Species List for Hot Springs National Park

Family	Scientific Name	Common Name
Acanthaceae	*Ruellia pedunculata*	stalked wild petunia
Aceraceae	*Acer negundo*	boxelder
	Acer rubrum	red maple
Agavaceae	*Yucca arkansana*	Arkansas yucca
Anacardiaceae	*Rhus aromatica*	fragrant sumac
	Rhus copallinum	winged sumac
	Rhus glabra	smooth sumac
	Toxicodendron pubescens	Atlantic poison oak
	Toxicodendron radicans	eastern poison ivy
Annonaceae	*Asimina triloba*	pawpaw
Apiaceae	*Chaerophyllum tainturieri*	hairyfruit chervil
	Osmorhiza claytonii	Clayton's sweetroot
	Sanicula canadensis	Canadian blacksnakeroot
	Sanicula odorata	clustered blacksnakeroot
	Tirilis japonica	erect hedgeparsley
Apocynaceae	*Vinca major*	bigleaf periwinkle
	Vinca minor	common periwinkle
Aquifoliaceae	*Ilex decidua*	possumhaw
	Ilex opaca	American holly
	Ilex vomitoria	yaupon
Araceae	*Arisaema dracontium*	green dragon
Araliaceae	*Aralia spinosa*	devil's walkingstick
	Hedera helix	English ivy
	Panax quinquefolius	American ginseng
Aristolochiaceae	*Aristolochia serpentaria*	Virginia snakeroot
Asclepiadaceae	*Asclepias quadrifolia*	fourleaf milkweed
	Asclepias tuberosa	butterfly milkweed
	Cynanchum laeve	honeyvine
	Matelea decipiens	oldfield milkvine
Aspleniaceae	*Asplenium platyneuron*	ebony spleenwort
Asteraceae	*Ageratina altissima*	white snakeroot
	Ambrosia artemisiifolia	annual ragweed
	Antennaria parlinii ssp. fallax	Parlin's pussytoes
	Antennaria plantaginifolia	woman's tobacco
	Bidens sp.	beggarticks
	Cirsium altissimum	tall thistle
	Conyza canadensis	Canadian horseweed
	Coreopsis grandiflora	largeflower tickseed

Family	Scientific Name	Common Name
	Echinacea pallida	pale purple coneflower
	Erigeron annuus	eastern daisy fleabane
	Erigeron strigosus	prairie fleabane
	Gamochaeta purpurea	spoonleaf purple everlasting
	Helianthus hirsutus	hairy sunflower
	Hieracium gronovii	queendevil
	Krigia biflora	twoflower dwarfdandelion
	Krigia dandelion	potato dwarfdandelion
	Lactuca canadensis	Canada lettuce
	Lactuca floridana	woodland lettuce
	Liatris aspera	tall blazing star
	Liatris pycnostachya	prairie blazing star
	Liatris squarrosa	scaly blazing star
	Parthenium integrifolium	wild quinine
	Packera obovata	roundleaf ragwort
	Pityopsis graminifolia	narrowleaf silkgrass
	Prenanthes altissima	tall rattlesnakeroot
	Solidago altissima	Canada goldenrod
	Solidago arguta	Atlantic goldenrod
	Sonchus asper	spiny sowthistle
	Solidago buckleyi	Buckley's goldenrod
	Solidago caesia	wreath goldenrod
	Solidago hispida	hairy goldenrod
	Solidago nemoralis	gray goldenrod
	Solidago petiolaris	downy ragged goldenrod
	Solidago radula	western rough goldenrod
	Solidago ulmifolia	elmleaf goldenrod
	Symphyotrichum anomalum	manyray aster
	Symphyotrichum cordifolium	common blue wood aster
	Symphyotrichum lateriflorum	calico aster
	Symphyotrichum lateriflorum var. lateriflorum	calico aster
	Symphyotrichum patens	late purple aster
	Symphyotrichum turbinellum	smooth violet prairie aster
	Vernonia baldwinii	Baldwin's ironweed
	Verbesina virginica	white crownbeard
Balsaminaceae	*Impatiens sp.*	touch-me-not
Berberidaceae	*Nandina domestica*	sacred bambo
	Podophyllum peltatum	mayapple
Betulaceae	*Carpinus caroliniana*	American hornbeam

Family	Scientific Name	Common Name
	Ostrya virginiana	hophornbeam
Bignoniaceae	*Bignonia capreolata*	crossvine
	Campsis radicans	trumpet creeper
Boraginaceae	*Myosotis verna*	spring forget-me-not
Brassicaceae	*Arabis canadensis*	sicklepod
	Streptanthus maculatus	clasping jewelflower
Cactaceae	*Opuntia humifusa*	devil's-tongue
Campanulaceae	*Lobelia cardinalis*	cardinalflower
	Triodanis perfoliata	clasping Venus' looking-glass
Caprifoliaceae	*Lonicera flava*	yellow honeysuckle
	Lonicera japonica	Japanese honeysuckle
	Symphoricarpos orbiculatus	coralberry
	Viburnum rufidulum	rusty blackhaw
Caryophyllaceae	*Silene stellata*	widowsfrill
	Stellaria media	common chickweed
Celastraceae	*Euonymus americanus*	bursting-heart
	Euonymus atropurpureus	burningbush
Clusiaceae	*Hypericum hypericoides*	St. Andrew's cross
	Hypericum prolificum	shrubby St. Johnswort
	Hypericum punctatum	spotted St. Johnswort
Commelinaceae	*Commelina communis*	Asiatic dayflower
	Tradescantia hirsutiflora	hairyflower spiderwort
Convolvulaceae	*Ipomoea pandurata*	man of the earth
Cornaceae	*Cornus florida*	flowering dogwood
	Cornus obliqua	silky dogwood
	Nyssa sylvatica	blackgum
Cupressaceae	*Juniperus virginiana*	eastern redcedar
Cyperaceae	*Carex amphibola*	eastern narrowleaf sedge
	Carex blanda	eastern woodland sedge
	Carex cephalophora	oval-leaf sedge
	Carex digitalis	slender woodland sedge
	Carex hirsutella	fuzzy wuzzy sedge
	Carex muehlenbergii	Muhlenberg's sedge
	Carex nigromarginata	black edge sedge
	Carex retroflexa	reflexed sedge
	Carex sp.	sedge
	Carex umbellata	parasol sedge
	Cyperus lupulinus	Great Plains flatsedge
	Scleria oligantha	littlehead nutrush

Family	Scientific Name	Common Name
Dennstaedtiaceae	*Pteridium aquilinum*	western brackenfern
Dioscoreaceae	*Dioscorea quaternata*	fourleaf yam
	Dioscorea villosa	wild yam
Dryopteridaceae	*Polystichum acrostichoides*	Christmas fern
Ebenaceae	*Diospyros virginiana*	common persimmon
Ericaceae	*Vaccinium arboreum*	farkleberry
	Vaccinium pallidum	Blue Ridge blueberry
	Vaccinium stamineum	deerberry
Euphorbiaceae	*Acalypha gracilens*	slender threeseed mercury
	Acalypha virginica	Virginia threeseed mercury
	Croton monanthogynus	prairie tea
	Euphorbia corollata	flowering spurge
Fabaceae	*Albizia julibrissin*	silktree
	Amphicarpaea bracteata	American hogpeanut
	Amorpha fruticosa	false indigo bush
	Baptisia bracteata var. leucophaea	longbract wild indigo
	Cercis canadensis	eastern redbud
	Chamaecrista nictitans ssp. nictitans var. nictitans	sensitive partridge pea
	Clitoria mariana	Atlantic pigeonwings
	Desmodium glutinosum	pointedleaf ticktrefoil
	Desmodium laevigatum	smooth ticktrefoil
	Desmodium nudiflorum	nakedflower ticktrefoil
	Desmodium paniculatum	panicledleaf ticktrefoil
	Desmodium perplexum	perplexed ticktrefoil
	Galactia volubilis	downy milkpea
	Gleditsia triacanthos	honeylocust
	Lathyrus venosus	veiny pea
	Lespedeza cuneata	sericea lespedeza
	Lespedeza procumbens	trailing lespedeza
	Lespedeza stuevei	tall lespedeza
	Lespedeza virginica	slender lespedeza
	Robinia pseudoacacia	black locust
	Tephrosia virginiana	Virginia tephrosia
	Trifolium campestre	field clover
	Vicia caroliniana	Carolina vetch
	Wisteria	wisteria
Fagaceae	*Castanea pumila var. ozarkensis*	Ozark chinquapin
	Quercus alba	white oak
	Quercus falcata	southern red oak
	Quercus marilandica	blackjack oak

Family	Scientific Name	Common Name
	Quercus muehlenbergii	chinquapin oak
	Quercus phellos	willow oak
	Quercus rubra	northern red oak
	Quercus stellata	post oak
	Quercus velutina	black oak
Geraniaceae	*Geranium carolinianum*	Carolina geranium
Hamamelidaceae	*Hamamelis vernalis*	Ozark witchhazel
	Hamamelis virginiana	American witchhazel
	Liquidambar styraciflua	sweetgum
Hydrophyllaceae	*Phacelia bipinnatifida*	fernleaf phacelia
Iridaceae	*Iris cristata*	dwarf crested iris
Juglandaceae	*Carya alba*	mockernut hickory
	Carya cordiformis	bitternut hickory
	Carya glabra	pignut hickory
	Carya ovata	shagbark hickory
	Carya texana	black hickory
	Juglans nigra	black walnut
Juncaceae	*Luzula bulbosa*	bulbous woodrush
Lamiaceae	*Blephilia ciliata*	downy pagoda-plant
	Cunila origanoides	common dittany
	Monarda fistulosa	wild bergamot
	Monarda russeliana	redpurple beebalm
	Perilla frutescens	beefsteakplant
	Pycnanthemum albescens	whiteleaf mountainmint
	Salvia lyrata	lyreleaf sage
	Scutellaria elliptica	hairy skullcap
	Scutellaria ovata	heartleaf skullcap
Lauraceae	*Lindera benzoin*	northern spicebush
Lauraceae	*Sassafras albidum*	sassafras
Liliaceae	*Allium sp.*	onion
	Maianthemum racemosum	feathery false lily of the valley
	Narcissus	daffodil
	Polygonatum biflorum	smooth Solomon's seal
Magnoliaceae	*Magnolia grandiflora*	southern magnolia
Menispermaceae	*Cocculus carolinus*	Carolina coralbead
Moraceae	*Maclura pomifera*	osage orange
	Morus rubra	red mulberry
Oleaceae	*Fraxinus americana*	white ash
	Fraxinus pennsylvanica	green ash

Family	Scientific Name	Common Name
	Ligustrum sinense	Chinese privet
Ophioglossaceae	*Botrychium virginianum*	rattlesnake fern
Oxalidaceae	*Oxalis stricta*	common yellow oxalis
	Oxalis violacea	violet woodsorrel
Passifloraceae	*Passiflora lutea*	yellow passionflower
Pinaceae	*Pinus echinata*	shortleaf pine
Plantaginaceae	*Plantago virginica*	Virginia plantain
Platanaceae	*Platanus occidentalis*	American sycamore
Poaceae	*Aira elegans*	annual silver hairgrass
	Andropogon gerardii	big bluestem
	Andropogon virginicus	broomsedge bluestem
	Aristida dichotoma	churchmouse threeawn
	Aristida dichotoma var. curtissii	Curtis' threeawn
	Brachyelytrum erectum	bearded shorthusk
	Bromus pubescens	hairy woodland brome
	Chasmanthium latifolium	Indian woodoats
	Cynodon dactylon	Bermudagrass
	Dactylis glomerata	orchardgrass
	Danthonia spicata	poverty oatgrass
	Dichanthelium acuminatum var. lindheimeri	Lindheimer panicgrass
	Diarrhena americana	American beakgrain
	Dichanthelium boscii	Bosc's panicgrass
	Digitaria ciliaris	southern crabgrass
	Dichanthelium commutatum	variable panicgrass
	Dichanthelium dichotomum	cypress panicgrass
	Dichanthelium laxiflorum	openflower rosette grass
	Dichanthelium linearifolium	slimleaf panicgrass
	Elymus virginicus	Virginia wildrye
	Festuca paradoxa	clustered fescue
	Festuca subverticillata	nodding fescue
	Leersia virginica	whitegrass
	Lolium perenne	perennial ryegrass
	Paspalum dilatatum	dallisgrass
	Panicum virgatum	switchgrass
	Piptochaetium avenaceum	blackseed speargrass
	Poa annua	annual bluegrass
	Schedonorus arundinaceus	tall fescue
	Schizachyrium scoparium	little bluestem
	Sorghum halepense	Johnsongrass
	Sorghastrum nutans	Indiangrass

Family	Scientific Name	Common Name
	Sporobolus clandestinus	rough dropseed
	Sphenopholis obtusata	prairie wedgescale
	Vulpia octoflora	sixweeks fescue
Polemoniaceae	*Phlox divaricata*	wild blue phlox
	Phlox pilosa	downy phlox
Polygonaceae	*Polygonum sp.*	knotweed
	Polygonum scandens	climbing false buckwheat
	Polygonum virginianum	jumpseed
	Pleopeltis polypodioides	resurrection fern
Primulaceae	*Lysimachia lanceolata*	lanceleaf loosestrife
Pteridaceae	*Cheilanthes tomentosa*	woolly lipfern
Ranunculaceae	*Anemone virginiana*	tall thimbleweed
	Delphinium carolinianum ssp. carolinianum	Carolina larkspur
	Thalictrum thalictroides	rue anemone
Rhamnaceae	*Berchemia scandens*	Alabama supplejack
	Frangula caroliniana	Carolina buckthorn
Rosaceae	*Agrimonia parviflora*	harvestlice
	Agrimonia rostellata	beaked agrimony
	Amelanchier arborea	common serviceberry
	Crategus sp.	hawthorn
	Crataegus crus-galli	cockspur hawthorn
	Crataegus marshallii	parsley hawthorn
	Geum canadense	white avens
	Potentilla simplex	common cinquefoil
	Prunus americana	American plum
	Prunus mexicana	Mexican plum
	Prunus serotina	black cherry
	Pyrus calleryana	Callery pear
	Rosa arkansana	prairie rose
	Rosa multiflora	multiflora rose
	Rubus argutus	sawtooth blackberry
	Rubus flagellaris	northern dewberry
Rubiaceae	*Galium aparine*	stickywilly
	Galium arkansanum	Arkansas bedstraw
	Galium circaezans	licorice bedstraw
	Galium triflorum	fragrant bedstraw
	Mitchella repens	partridgeberry
Salicaceae	*Salix nigra*	black willow
Sapotaceae	*Sideroxylon lanuginosum*	gum bully
Scrophulariaceae	*Aureolaria flava var. flava*	smooth yellow false

Family	Scientific Name	Common Name
		foxglove
	Pedicularis canadensis	Canadian lousewort
	Veronicastrum virginicum	Culver's root
Simaroubaceae	*Ailanthus altissima*	tree of heaven
Smilacaceae	*Smilax bona-nox*	saw greenbrier
	Smilax glauca	cat greenbrier
Solanaceae	*Physalis virginiana*	Virginia groundcherry
Styracaceae	*Styrax grandifolius*	bigleaf snowbell
Thelypteridaceae	*Phegopteris hexagonoptera*	broad beechfern
Tiliaceae	*Tilia americana*	American basswood
Ulmaceae	*Celtis laevigata*	sugarberry
	Celtis occidentalis	common hackberry
	Celtis tenuifolia	dwarf hackberry
	Ulmus alata	winged elm
	Ulmus americana	American elm
Urticaceae	*Laportea canadensis*	Canadian woodnettle
Valerianaceae	*Valerianella radiata*	beaked cornsalad
Verbenaceae	*Callicarpa americana*	American beautyberry
	Glandularia canadensis	rose mock vervain
Violaceae	*Viola pedata*	birdfoot violet
	Viola sororia	common blue violet
	Viola striata	striped cream violet
	Viola triloba	three-lobe violet
Vitaceae	*Ampelopsis arborea*	peppervine
	Parthenocissus quinquefolia	Virginia creeper
	Vitis aestivalis	summer grape
	Vitis riparia	riverbank grape
	Vitis rotundifolia var. rotundifolia	muscadine
	Vitis vulpina	frost grape

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

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov