



# **Vegetation Classification and Mapping of Hopewell Culture National Historical Park, Ohio**

## *Project Report*

Natural Resource Report NPS/HOCU/NRR—2014/793



**ON THE COVER**

Mounds at Hopewell Culture National Historical Park.

Photograph by: Hopewell Culture National Historical Park

# **Vegetation Classification and Mapping of Hopewell Culture National Historical Park, Ohio**

## *Project Report*

Natural Resource Report NPS/HOCU/NRR—2014/793

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NPS Vegetation Inventory Program  
Hopewell Culture National Historical Park

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Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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## **Abstract/Executive Summary**

Hopewell Culture National Historic Park (HOCU) conserves remnants of mounds and other earthworks created by the Hopewell people within five separate units. These parcels lie at the boundary between the Western Allegheny Plateau to the south and the Eastern Cornbelt Plains (originally grassland and savanna) to the north. Most units lie on river terraces or low hills adjacent to stream floodplains.

A vegetation classification and mapping project was initiated in 2011 and completed in 2013. Protocols and products were produced following National Park Service Vegetation Inventory Program guidelines. Classification was based on 33 field plots and 54 georeferenced observation points. Mapping was based on air photo interpretation and heads-up digitizing of polygons. Accuracy assessment points obtained during 2013 verified that the map is 98.5% accurate.

Seven vegetation types were classified and mapped at HOCU, including four types specific to the park and three types that fit National Vegetation Classification association descriptions, two at the association level and one at the group level. Among these, the Appalachian Sugar Maple-Chinkapin Oak/Eastern Redbud Limestone Forest was in the best condition, and it occupied 34.1 acres (13.8 hectares) on the northeastern side of the Hopewell Mound Group unit. This area is unusual in that it lies on low hills rather than on relatively flat river floodplains and terraces. A low, rolling area to the west of this forest supported Ruderal Woodland and Ruderal Low Woodland/Shrubland vegetation. Three units supported narrow, linear patches of Silver Maple-Green Ash-Sycamore Floodplain Forest, and these patches comprised 38.9 acres (15.7 hectares). A ruderal type, Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation, occupied former croplands across most units of the park. This type accounted for 70.3% of the non-developed park area (587.8 acres, 237.9 hectares), and dominated the view shed across most park units.



## Introduction

### Hopewell Culture National Historical Park Vegetation Inventory Project

Hopewell Culture National Historical Park (HOCU) 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. HOCU had five separate units, mostly within river floodplains or terraces, and offers opportunities for restoration of tallgrass prairie communities over deep, tillable soils, which are rare on the modern landscape. In addition, small patches of woodland and forest occur on the park, mostly in areas adjacent to river terraces.

Each NPS Vegetation Mapping 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 Inventory 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](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](http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf)).

### ***Hopewell Culture National Historical Park***

Hopewell Culture National Historic Park conserves remnants of mounds, walls, ditches, and other earthworks created by the ancient Hopewell people between about 1 CE and 400 CE. The initial park location was expanded and now five separate areas are circumscribed: the Mound City Group, Hopeton Earthworks, High Bank Works, Hopewell Mound Group, and Seip Earthworks. The park units are all near Chillicothe, in southeast Ohio (Figure 1). All of these sites are situated near river floodplains, on the north edge of the Allegheny Plateau, just south of the Till Plains (Thornberry-Ehrlich 2013). According to the Environmental Protection Agency, the units are at the juncture between the Western Allegheny Plateau to the south and the Eastern

Cornbelt Plains to the north (website accessed  
at [ftp://ftp.epa.gov/wed/ecoregions/in/ohin\\_front.pdf](ftp://ftp.epa.gov/wed/ecoregions/in/ohin_front.pdf)).

## **Project Statistics**

### Field Work Summer 2011 - 2013:

Plot Sampling = 33

Plots sampled in June 2012 by MoRAP staff

Accuracy Assessment Points = 61

All collected in June and July of 2013 by Heartland Inventory and Monitoring  
Network and Hopewell Culture National Historic Park staff

Observation Points = 54

Collected between September 2011 and June 2012 by MoRAP staff

### Classification:

3 NVC Plant Associations

4 Park Special Vegetation Classes

1 Non-Vegetated Land-Use Class

### GIS Database 2011 - 2012:

Hopewell Culture National Historical Park = 1,287.9 acres (521.3 hectares)

Base Imagery used for mapping (acquired by MoRAP):

2007, Ross County, OH, leaf off, CIR, 1 m

2010, Ross County, OH, leaf-on, true color, 1 m

Additional Imagery acquired and viewed by MoRAP:

Bing Maps

2010, Ross County, OH, SPOT, leaf off, CIR, 5m

Minimum Mapping Unit = 0.5 hectare

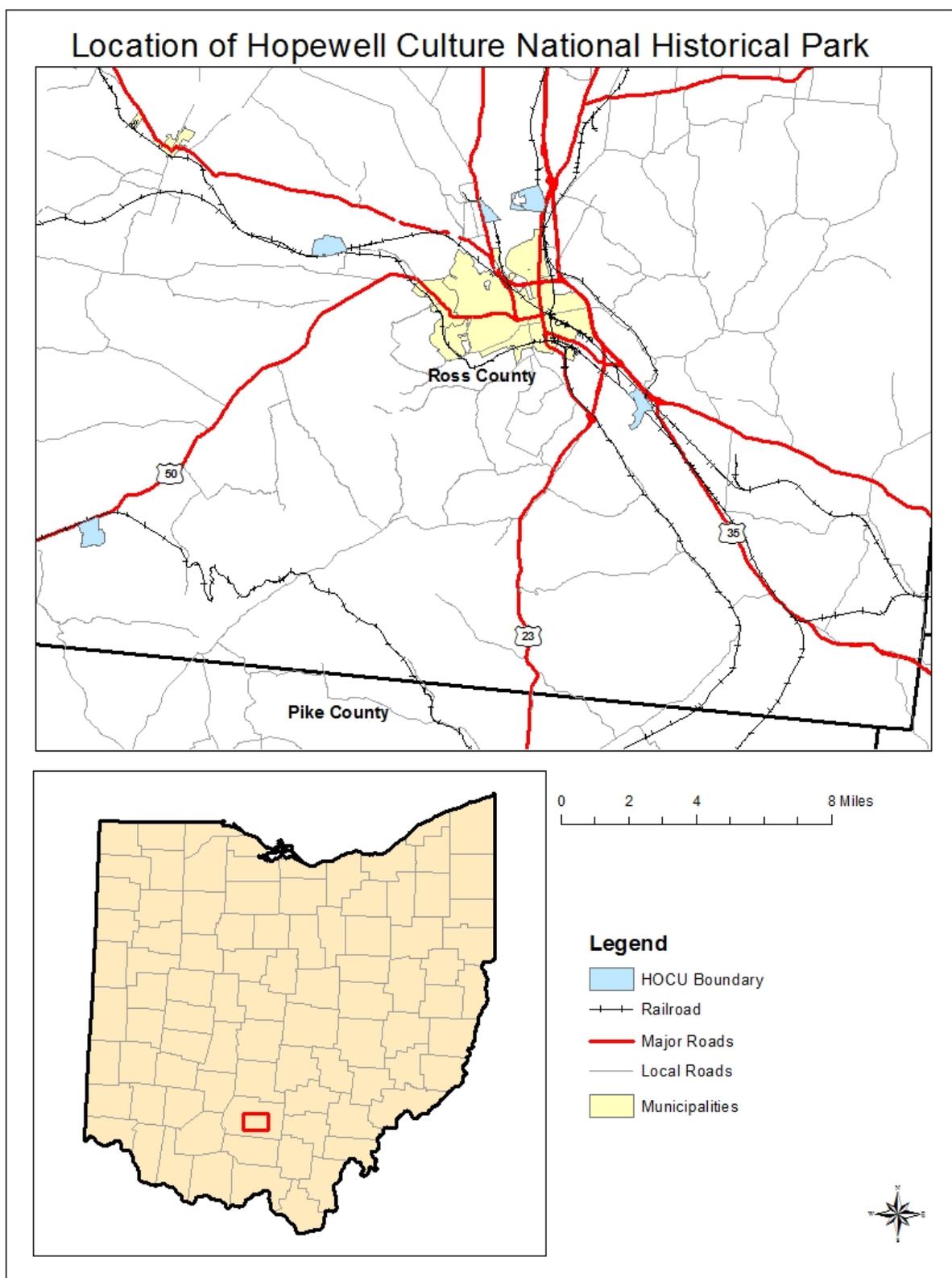
Minimum Patch Size=.0003 hectares

Total Size = 142 Polygons

Average Polygon Size = 9.1 acres (3.68 hectares)

Overall Thematic Accuracy = 98.5%

Project Completion Date: 12/2013



**Figure 1.** Location of Hopewell Culture National Historic Park.

## Methods

Hopewell Culture National Historical Park, at 1,288 acres, is a small park as defined by sampling design protocols (TNC and ESRI 1994), so most of the mapped vegetation polygons were visited for this study. 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 HOCU 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 Inventory Program staff, and coordinated Accuracy Assessment tasks. HOCU 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 2009 et al., Lea 2011, National Park Service 2011). The application of these methods to HOCU is outlined below.

General information on soils and setting were collected for HOCU, and this information together with National Agriculture Imagery Program (NAIP) air photos and field-collected observation data were used to inform the design of field surveys and ultimately vegetation classification and mapping (Figure 3). Observation points consisted of brief visits (less than 15 minute) by

ecologists from MoRAP where general information on vegetation structure and composition was noted.

Vegetation data were collected at 33 plots by MoRAP staff in June of 2012 (Figure 4). In the lab, the locations of plots were randomly placed within the following general strata based on field observation points and viewing of air photos and digital soil surveys (available at <http://soildatamart.nrcs.usda.gov/>): woodland and forest over moist soils, woodland and forest over better-drained soils, shrubland and open woodland, restored prairie, and non-native grassland. Plots were located >30 m from an obvious land cover edge, and for each point 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), shrublands and open woodlands with a 10 m x 20 m plot (200 sq m), and herbaceous vegetation with a 5 m x 20 m plot (100 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

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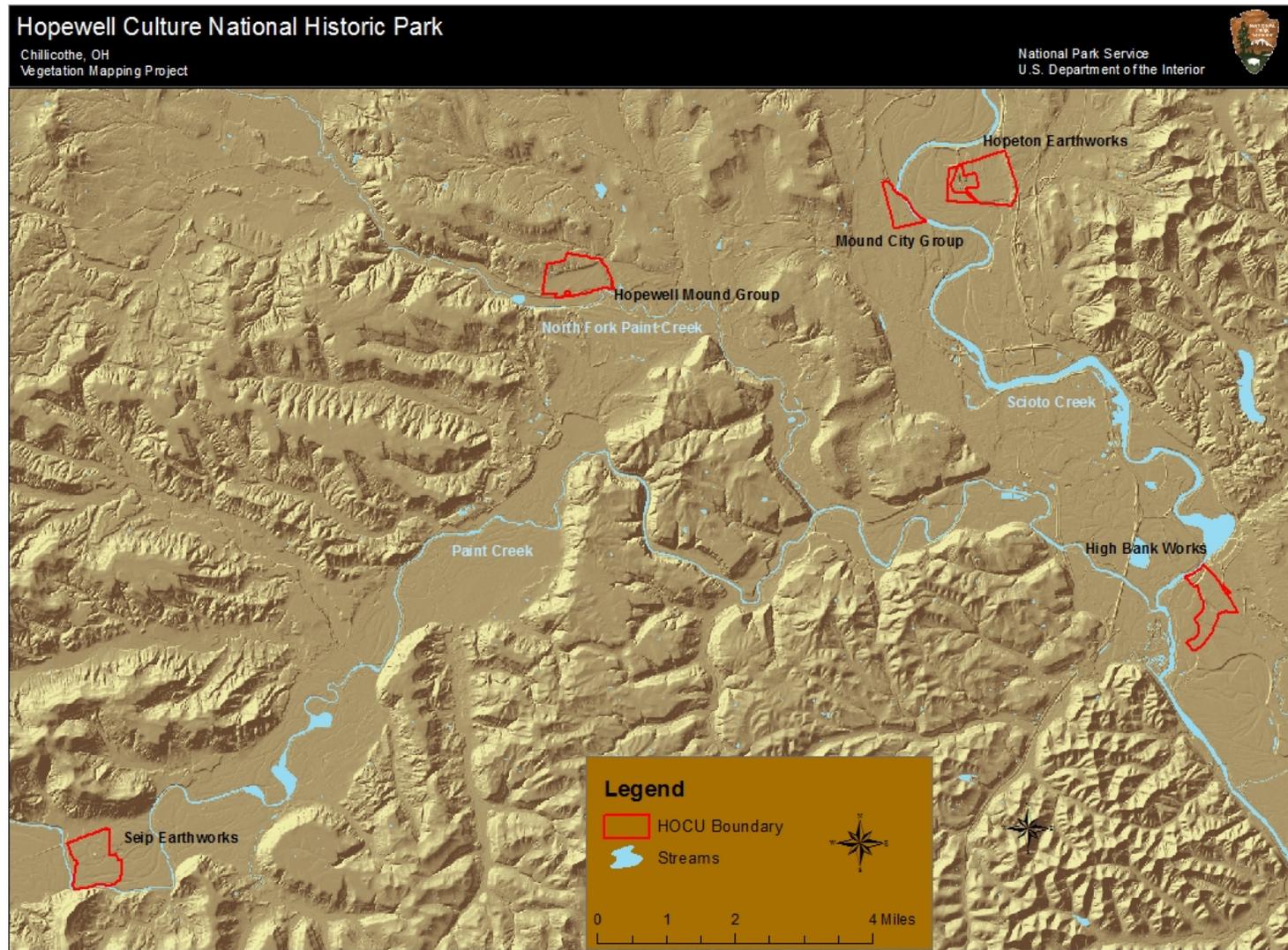


Figure 2. Map of the Hopewell Culture National Historic Park.

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Hopewell Culture National Historical Park

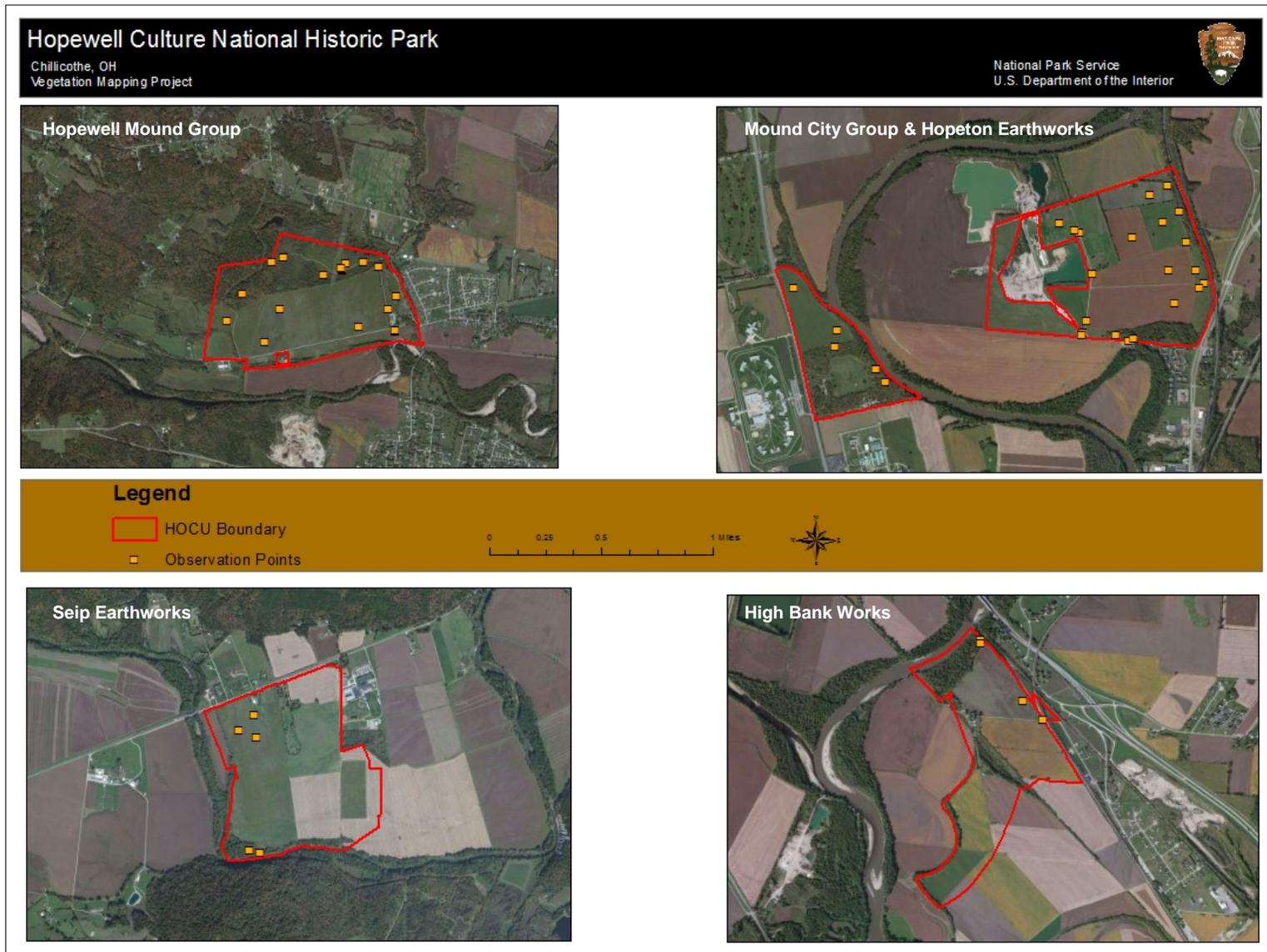


Figure 3. Location of 54 observation points collected in Hopewell Culture National Historic Park.

NPS Vegetation Inventory Program  
Hopewell Culture National Historical Park

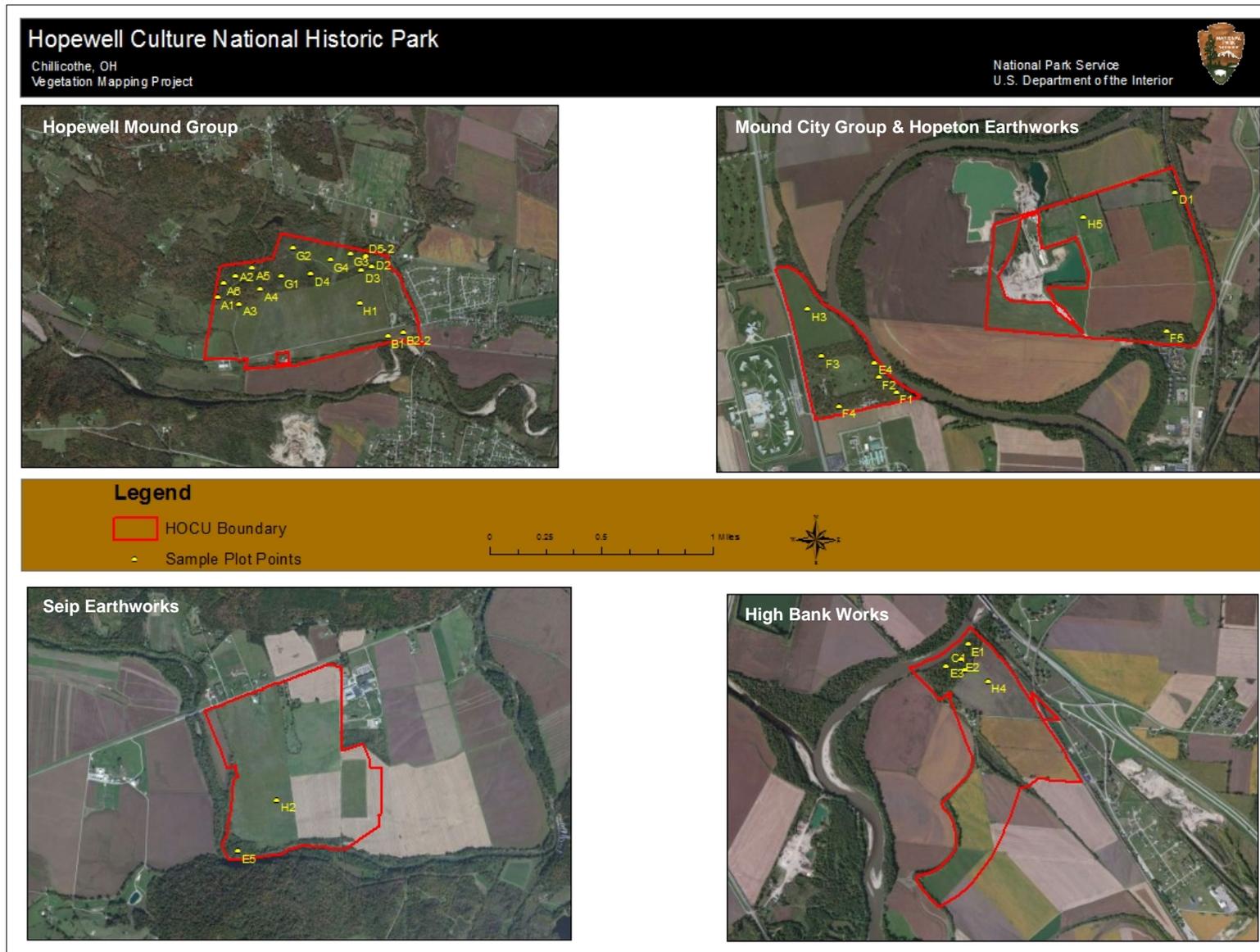


Figure 4. Location of 33 sample plot in Hopewell Culture National Historic Park.

### **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.

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

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

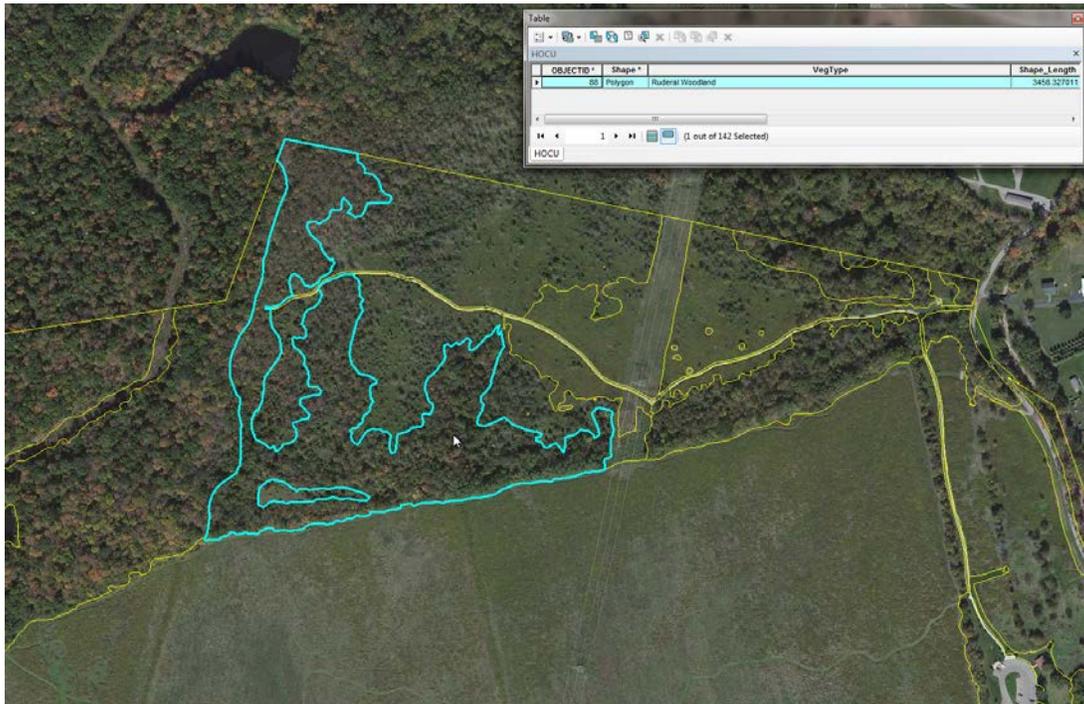
Use of this formula reduces the effects of overlapping cover in various strata. We used a log transformation to standardize cover values using the formula  $\log(\text{cover} + 1)$ . Bray-Curtis dissimilarity was used as the distance metric for the cluster and ordination analyses (Legendre and Legendre 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>. Where the observed HOCU vegetation did not fit descriptions of natural associations described for Ohio, ruderal types were assigned.

Once the classification was finalized, a dichotomous key was developed by MoRAP for use during the Accuracy Assessment (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.

### **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 NAIP, see [http://www.fsa.usda.gov/Internet/FSA\\_File/naip\\_2009\\_info\\_final.pdf](http://www.fsa.usda.gov/Internet/FSA_File/naip_2009_info_final.pdf). This included 2010 leaf-on true color 1 m resolution photos, and 2007 leaf-off color infrared (CIR) 1 m resolution photos.



**Figure 5.** Digitization of hand drawn objects.

### ***Accuracy Assessment***

Thematic accuracy assessment (AA) was conducted by HOCU staff. Methods and analysis for the accuracy assessment of vegetation mapping at HOCU were based on NPS standards (Lea and Curtis 2010). Thematic or attribute accuracy of mapped vegetation types were assessed independently following the completion of the vegetation mapping inventory by the lead authors. Representative sites were identified and visited to determine if interpreted mapped types 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 maps suitability for different applications.

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

NPS Vegetation Inventory Program  
Hopewell Culture National Historical Park

**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
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 m from the park boundary and 80 m from another point for larger polygons. 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). Accuracy assessment field work was completed during June 2013. Field staff was

provided with a GPS unit, dichotomous key for mapped types and vegetation definitions for each mapped type.

Plot shape and size varied according to the patch extent of the mapped vegetation type containing the sample point. Circular 0.25 hectare (28 m radius) plots were used for most patches. A mix of circular and rectangular 0.1 hectare plots were used for small patches and linear patch types, respectively. A circular plot size of 0.5 hectare (40 m radius) was used to capture information for the larger homogenous patches. In all cases, the plot size selection was made to ensure the most area was considered within a homogenous mapped type patch.

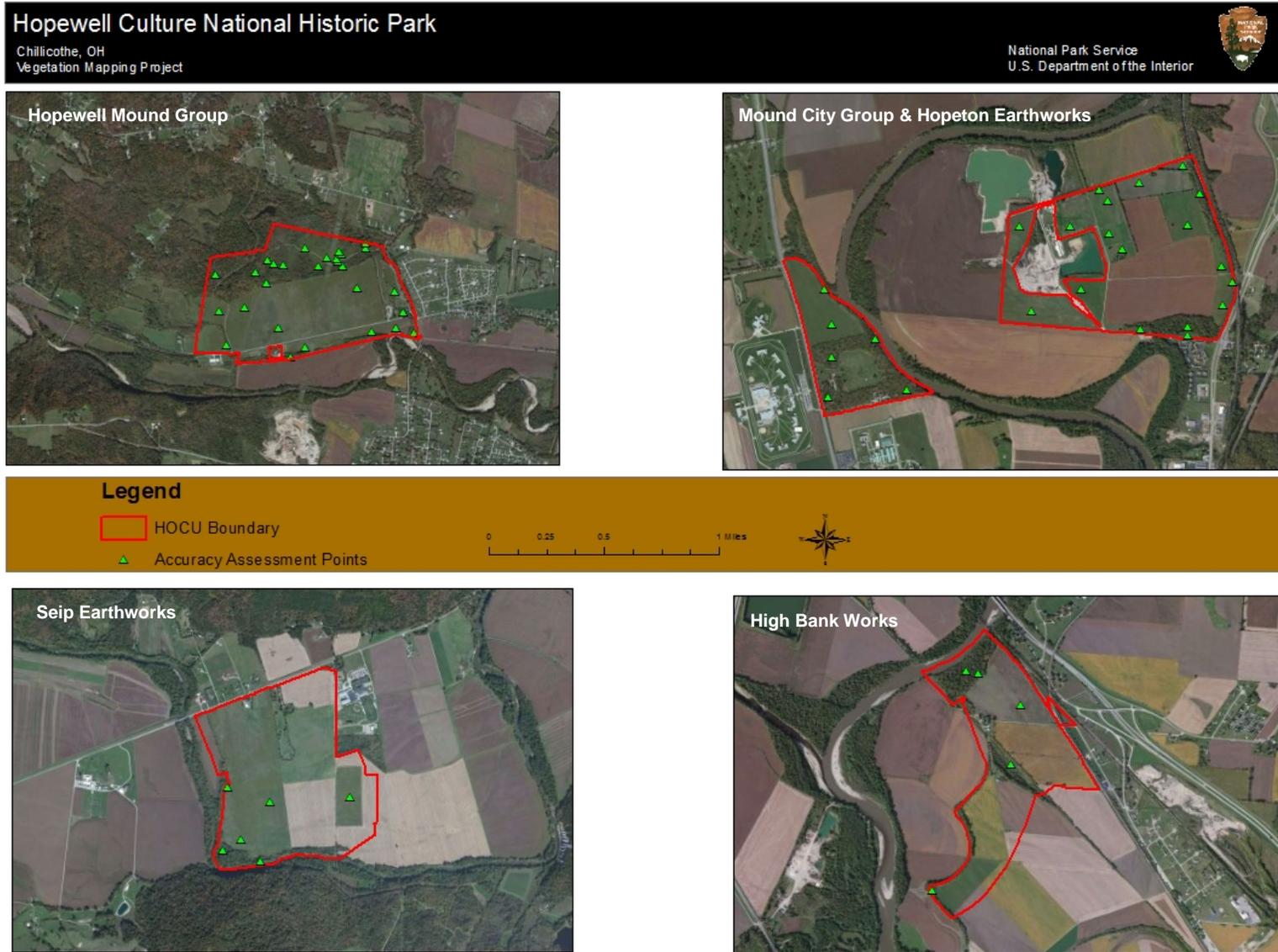
Field staff recorded plot size and shape, positional accuracy and vegetation classification at each point (Accuracy Assessment Field Form, Appendix D). Field data from the 61 points were entered into the PLOTS database and underwent quality assurance/quality control (QA/QC) verification. In addition, 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 Hopewell Culture National Historical Park.

<b>Statistic</b>	<b>Description</b>
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.

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**Figure 6.** Locations of Accuracy Assessment plots for Hopewell Culture National Historic Park.

## Results

### Vegetation Classification

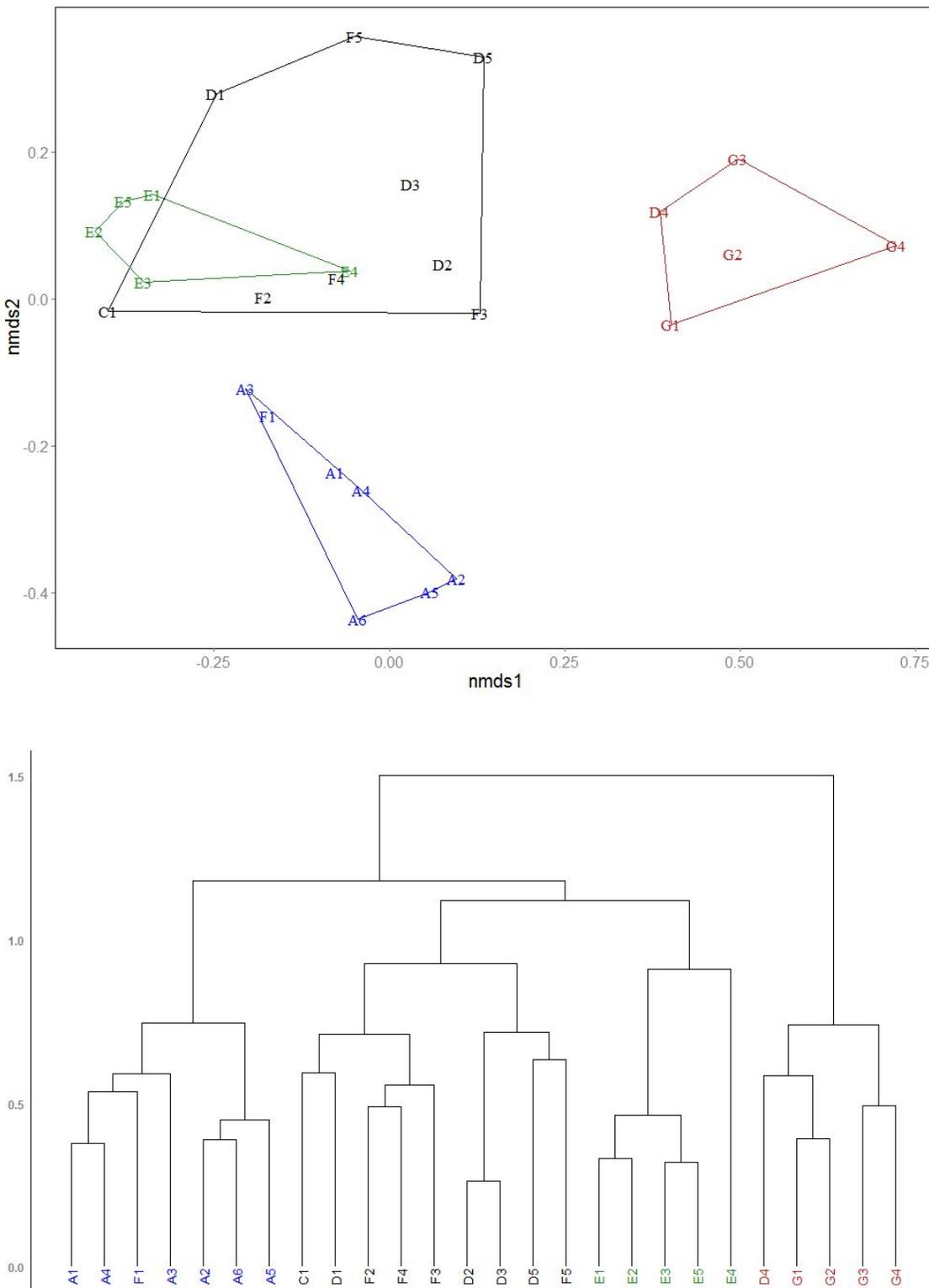
Seven vegetation types were identified at HOCU, and developed land made up an eighth type. Six types were distinguished based on ordination and cluster analyses (Figure 7), and one type, Eastern North American Wet Meadow Group, was recognized based on field observation points. This type consisted of five roughly circular patches less than 30 feet (9.1 meters) in diameter. Based on initial analysis of all 33 plots, seven plots were recognized as representing two types, Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation (five) and Restored Tallgrass Prairie (two). These plots were removed and data for the remaining 26 plots were re-analyzed (Figure 7). From the second round of analyses, four more types were recognized. Two of the types from the classification clearly fit association concepts from the national vegetation classification (see website at <http://usnvc.org/explore-classification/>). One of these was a ruderal grassland, while the other was an Appalachian forest type (Table 4). Other recognized types did not clearly fit national vegetation classification association concepts, mainly because they were ruderal. During the sampling efforts a total of 209 taxa were recorded (Appendix E).

The ordination depicts plot locations in two-dimensional space. The four types are:

green – Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest group,  
black – Ruderal Woodland,  
blue — Appalachian Sugar Maple-Chinkapin Oak Limestone Forest, and  
red - Ruderal Low Woodland/Shrubland.

The Silver Maple Forest and Ruderal Woodland types appear mixed in the ordination, but were clearly separated along the third ordination axis and in the cluster dendrogram. In addition, the cluster analysis placed Plot F1 with the Appalachian Forest group, but based on the ordination and examination of the original data, this plot was determined to best represent the Ruderal Woodland type.

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**Figure 7.** Ordination analysis and cluster dendrogram for twenty-six plots representing four types. The black and green types appear mixed in two dimensions, but were clearly separated on the third ordination axis.

## Digital Imagery and Interpretation

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

### Vegetation Map

A total of 1,287.9 acres (521.3 hectares) are within the sampled boundaries of HOCU (Figure 8). The standard minimum mapping unit for NPS vegetation inventory projects is defined as 0.5 hectare, although several mapped polygons were smaller for HOCU. Ruderal grasslands within the Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation type dominated the landscape of HOCU, comprising 587.8 acres (237.9 hectares), or 70.3% of the non-developed area. Ruderal woodland made up 135.8 acres (55.1 hectares), or an additional 16.2% of the undeveloped area. Restored tallgrass prairie and eastern North American Wet Meadow each made up less than 1% of the area, and the remaining types made up about 4% each. The Appalachian Sugar Maple-Chinkapin Oak Limestone Forest appeared most natural of all types mapped, and occupied 34.1 acres (13.8 hectares) in two patches separated by a narrow, open right of way. Developed land accounted for 441.5 acres (178.7 hectares), or 34.2% of the park. A total of 142 polygons were mapped, with an average area of 9.1 acres (3.68 hectares).

### Accuracy Assessment

The 2013 accuracy assessment for HOCU was limited to the 836.3 acres (338.5 hectares) of natural and semi-natural vegetation within the park boundary. A total of 61 points were required to accurately evaluate the seven natural and semi-natural mapped vegetation types identified in the park (Table 4). Navigational error (positional accuracy) of the GPS unit ranged from 2-5 meters for the 61 accuracy assessment points.

**Table 4.** Mapped types identified at Hopewell Culture National Historical Park.

NVC Identifier	Mapped Type Name	Scientific Name / Description	Number of Polygons	Acres	Hectares
<b>Forest and Woodlands</b>					
CEGL006017	Appalachian Sugar Maple-Chinkapin Oak/Eastern Redbud Limestone Forest	<i>Acer saccharum-Quercus muehlenbergii/Cercis canadensis</i> Limestone Forest	2	34.1	13.8
None assigned	Ruderal Low Woodland/Shrubland	<i>Elaeagnus umbellata - Gleditsia triacanthos / Rubus pensilvanica</i> Woodland / Shrubland	18	35.6	14.4
similar to CEGL004693 (no description available)	Ruderal Woodland	<i>Juglans nigra-Celtis occidentalis</i> Forest	41	135.8	55
None assigned	Silver Maple-Green Ash-Sycamore Floodplain Forest Group	<i>Acer saccharinum-Fraxinus pennsylvanica-Platanus occidentalis-Celtis</i> spp. Forest	4	38.9	15.7

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NVC Identifier	Mapped Type Name	Scientific Name / Description	Number of Polygons	Acres	Hectares
<b>Herbaceous Vegetation</b>					
None assigned	Eastern North American Wet Meadow Group	<i>Eleocharis</i> spp.- <i>Carex</i> spp. - <i>Polygonum</i> spp. Herbaceous Wetland	5	0.05	0.02
CEGL006107	Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation	<i>Dactylis glomerata</i> - <i>Phleum pratense</i> - <i>Festuca</i> spp.- <i>Solidago</i> spp. Herbaceous Vegetation	30	587.8	237.9
None assigned	Restored Tallgrass Prairie	<i>Andropogon gerardii</i> Herbaceous Vegetation	1	4.0	1.6
<b>Land Use/Land Cover</b>					
None assigned	Developed Land	buildings, parking lots, picnic areas, roads, cemetery, garden, sewage application field	30	441.5	178.7
None assigned	Water	man-made, spring-fed pond	11	10.1	4.1
Total Land Use/Land Cover			41	451.6	182.8
Total Natural Vegetation			101	836.3	338.5
<b>Totals</b>			<b>142</b>	<b>1287.9</b>	<b>521.3</b>

Overall accuracy of the final error matrix was 98.5% (the 90% confidence interval was between 96.9 and 100.2%) for the natural and semi-natural mapped vegetation types at HOCU (Appendix A). Omission accuracy (map producer's error) was 100% for all types except Ruderal Woodland/Shrubland (74.2%). Commission accuracy (user's error) was 100% for all map classes except Ruderal Woodland (90.9%). Two accuracy assessment points originally mapped as Ruderal Woodland/Shrubland were keyed to Ruderal Woodland in the field. Therefore, 59 of the 61 accuracy assessment points were assigned correctly. Kappa Index, or the random chance polygons were assigned correctly, was 93.2% (Appendix A).

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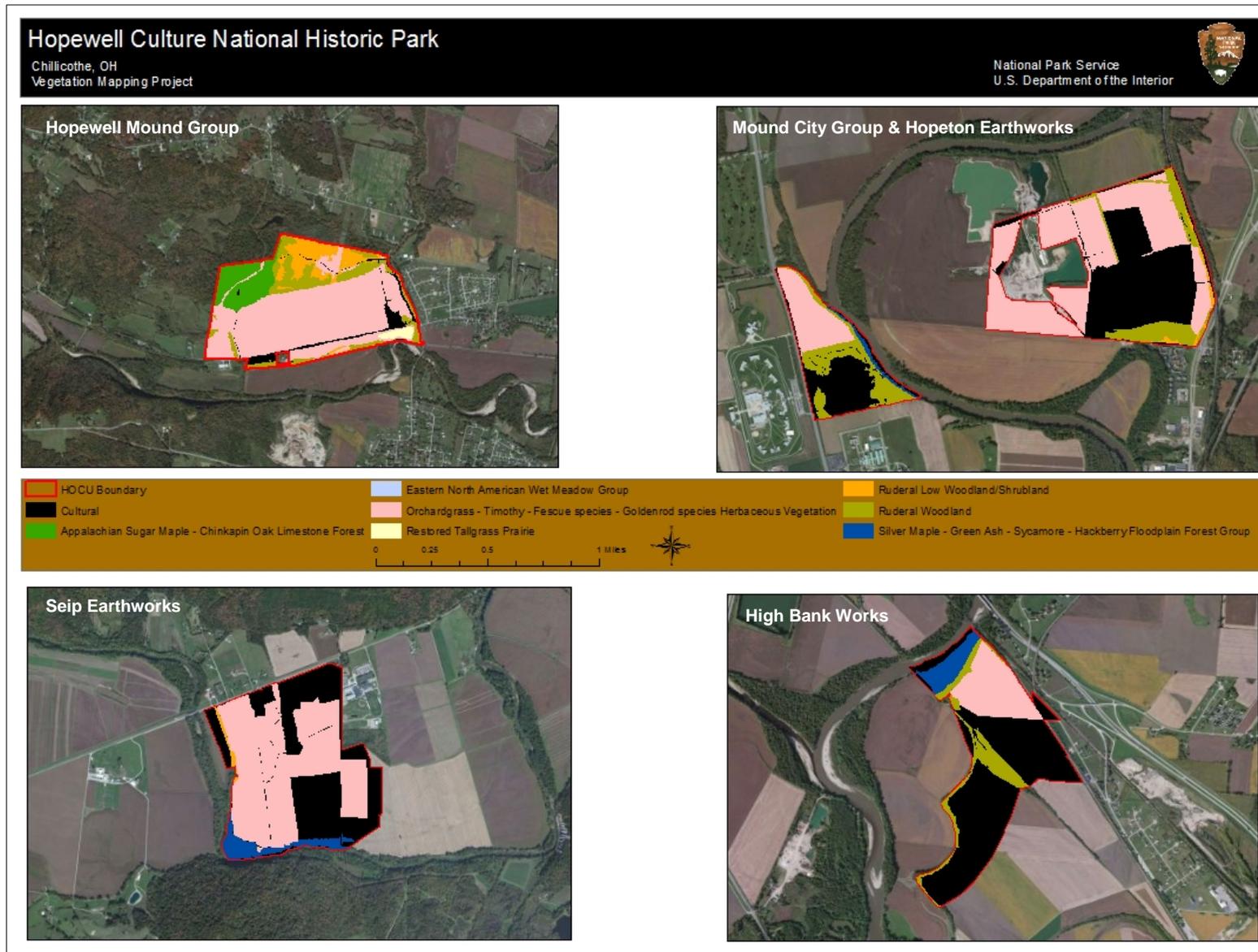


Figure 8. Vegetation Classification for Hopewell Culture National Historic Park.

## Vegetation Associations

### Mapped Type Name: Appalachian Sugar Maple-Chinkapin Oak Limestone Forest

**Macrogroup:** M012. Central Oak-Hardwood & Pine Forest

**Group:** G015. Chinkapin Oak-Ash-Red-cedar Alkaline Forest Group

**Association:** CEGL006017

**Type Common Name:** Sugar Maple-Chinkapin Oak/Eastern Redbud Limestone Forest

**Type Scientific Name:** *Acer saccharum-Quercus muehlenbergii/Cercis canadensis* Forest



**Figure 9.** Appalachian Sugar Maple-Chinkapin Oak Limestone Forest at Hopewell Culture National Historical Park.

**Global Summary:** This type is within a group that circumscribes relatively dry calcareous woodlands and occurs across the eastern United States and into southern Canada. Chinkapin oak (*Quercus muehlenbergii*) may be associated with a variety of hardwood species and with eastern redcedar (*Juniperus virginiana*) (Figure 9). Communities within this group cover large areas in the Southern Ridge and Valley ecoregion and in the Central Valley of Tennessee, and generally occur in smaller, often better-drained, patches elsewhere. This association is found mainly in the Central Appalachians and adjacent areas.

**Environmental Description:** At HOCU, this type was limited to a small area of upland, low, rolling hills on the northwest corner of the Hopewell Mound unit. Soils were generally well-drained and calcareous, and this was a dry to dry-mesic, closed canopy forest.

**Vegetation Description:** This was a maturing, mainly closed-canopy forest with an understory that contained both weedy and mature-forest species. Sugar maple (*Acer saccharum*) was the dominant overstory tree, followed by chinkapin oak (*Quercus muehlenbergii*) and white oak (*Quercus alba*). Pawpaw (*Asimina triloba*), common hackberry (*Celtis occidentalis*), and white ash (*Fraxinus americana*) were common small trees in the understory. Several weedy species, including multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and honeylocust (*Gleditsia triacanthos*) were also represented in the shrub layer. Common herbaceous components included white snakeroot (*Ageratina altissima*), Canadian honewort (*Cryptotaenia canadensis*), nodding fescue (*Festuca subverticillata*), stickywilly (*Galium aparine*), spring avens (*Geum vernum*), clustered blacksnakeroot (*Sanicula odorata*), and bristly greenbrier (*Smilax tamnoides*) (Table 5).

**Most Abundant Species:**

**Table 5.** Species found in at least two of six plots within the Appalachian Sugar Maple-Chinkapin Oak Limestone Forest vegetation type.

Appalachian Sugar Maple-Chinkapin Oak Limestone Forest			
Scientific Name	Common Name	Frequency	%Cover
Tree Layer			
<i>Acer saccharum</i>	sugar maple	100%	43.83
<i>Carya ovata</i>	shagbark hickory	33%	3.00
<i>Fraxinus americana</i>	white ash	33%	3.00
<i>Juglans nigra</i>	black walnut	50%	7.00
<i>Quercus alba</i>	white oak	33%	15.00
<i>Quercus muehlenbergii</i>	chinkapin oak	50%	7.00
Shrub Layer			
<i>Aesculus glabra</i>	Ohio buckeye	50%	2.17
<i>Asimina triloba</i>	pawpaw	100%	3.33
<i>Carya cordiformis</i>	bitternut hickory	67%	0.50
<i>Celtis occidentalis</i>	common hackberry	67%	4.76
<i>Cercis canadensis</i>	eastern redbud	33%	0.50
<i>Fraxinus americana</i>	white ash	83%	4.90
<i>Gleditsia triacanthos</i>	honeylocust	33%	0.50
<i>Lonicera japonica</i>	Japanese honeysuckle	33%	0.50
<i>Morus rubra</i>	red mulberry	33%	0.50
<i>Parthenocissus quinquefolia</i>	Virginia creeper	67%	1.75
<i>Prunus serotina</i>	black cherry	33%	0.50
<i>Rosa multiflora</i>	multiflora rose	100%	0.50
<i>Ulmus americana</i>	American elm	33%	0.50
<i>Vitis vulpina</i>	frost grape	33%	0.50
Herbaceous Layer			
<i>Ageratina altissima</i>	white snakeroot	83%	7.30

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<b>Appalachian Sugar Maple-Chinkapin Oak Limestone Forest</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Frequency</b>	<b>%Cover</b>
<i>Agrimonia rostellata</i>	beaked agrimony	33%	0.50
<i>Alliaria petiolata</i>	garlic mustard	50%	21.17
<i>Amphicarpaea bracteata</i>	American hogpeanut	33%	0.50
<i>Arisaema triphyllum</i>	Jack in the pulpit	33%	0.50
<i>Botrychium virginianum</i>	rattlesnake fern	50%	0.50
<i>Carex muehlenbergii</i>	Muhlenberg's sedge	33%	0.50
<i>Carex nigromarginata</i>	black edge sedge	33%	0.50
<i>Carex retroflexa</i>	reflexed sedge	33%	0.50
<i>Circaea lutetiana</i>	broadleaf enchanter's nightshade	50%	0.50
<i>Cryptotaenia canadensis</i>	Canadian honewort	100%	1.75
<i>Elymus virginicus</i>	Virginia wildrye	83%	18.20
<i>Festuca subverticillata</i>	nodding fescue	100%	1.75
<i>Galium aparine</i>	stickywilly	83%	0.50
<i>Galium circaezans</i>	licorice bedstraw	33%	0.50
<i>Galium concinnum</i>	shining bedstraw	67%	0.50
<i>Galium triflorum</i>	fragrant bedstraw	33%	0.50
<i>Geum canadense</i>	white avens	33%	0.50
<i>Geum vernum</i>	spring avens	100%	0.50
<i>Hackelia virginiana</i>	beggarslice	50%	0.50
<i>Hydrophyllum appendiculatum</i>	great waterleaf	50%	0.50
<i>Impatiens spp.</i>	touch-me-not	67%	4.13
<i>Leersia virginica</i>	whitegrass	33%	0.50
<i>Lonicera maackii</i>	Amur honeysuckle	50%	0.50
<i>Maianthemum racemosum</i>	feathery false lily of the valley	33%	0.50
<i>Menispermum canadense</i>	common moonseed	67%	0.50
<i>Osmorhiza claytonii</i>	Clayton's sweetroot	33%	0.50
<i>Packera obovata</i>	roundleaf ragwort	33%	0.50
<i>Phryma leptostachya</i>	American lopseed	67%	0.50
<i>Pilea pumila</i>	Canadian clearweed	33%	0.50
<i>Poa pratensis</i>	Kentucky bluegrass	50%	0.50
<i>Podophyllum peltatum</i>	mayapple	67%	1.75
<i>Polemonium reptans</i>	Greek valerian	33%	0.50
<i>Polygonum virginianum</i>	jumpseed	67%	0.50
<i>Ruellia strepens</i>	limestone wild petunia	50%	0.50
<i>Sanguinaria canadensis</i>	bloodroot	33%	0.50
<i>Sanicula odorata</i>	clustered blacksnakeroot	100%	20.92
<i>Smilax tamnoides</i>	bristly greenbrier	100%	0.50

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<b>Appalachian Sugar Maple-Chinkapin Oak Limestone Forest</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Frequency</b>	<b>%Cover</b>
<i>Symphyotrichum cordifolium</i>	common blue wood aster	67%	0.50
<i>Symphyotrichum lateriflorum</i>	calico aster	33%	0.50
<i>Toxicodendron radicans</i>	eastern poison ivy	50%	1.33
<i>Trifolium pratense</i>	red clover	50%	0.50
<i>Trillium sessile</i>	toadshade	50%	0.50
<i>Verbesina alternifolia</i>	wingstem	83%	0.50
<i>Viola sororia</i>	common blue violet	83%	0.50
<i>Viola striata</i>	striped cream violet	83%	3.40

**Mapped Type Name: Eastern North American Wet Meadow Group**

**Macrogroup:** M069. Eastern North American Wet Meadow & Marsh

**Group:** G112. Eastern North American Wet Meadow Group

**Association:** None

**Type Common Name:** Spikerush-Sedge-Smartweed Herbaceous Wetland

**Type Scientific Name:** *Eleocharis* spp.-*Carex* spp.-*Polygonum* spp. Herbaceous Wetland

Global Summary: This group includes a wide variety of shrubby and herbaceous shallow wetlands across the northern half of the eastern United States and into southern Canada. They occur in depressions, along the margins of water bodies, and along rivers. Water levels rarely reach more than 1.6 feet (0.5 meters), and these areas may dry out in the summer. These communities often have a dense cover of living vegetation during the growing season, and abundant litter on the ground from previous growing seasons.

Environmental Description: At HOCU, this type was limited to the Hopewell Mound Group unit, and consisted of five small, oval or nearly circular depressions, less than 30 feet (9.1 meters) in diameter. The depth of these depressions varied, and none was more than 350 feet (106 meters) from another, and the two most distant from each other were only 675 feet (206 meters) apart.

Vegetation Description: The communities within the five depressions varied due to differences in water depth both within each wetland depression and among the five wetlands. Ovate spikerush (*Eleocharis ovata*) was among the dominant species in three of the five wetlands. Sedges (*Carex stipata*, *Carex* spp.) and smartweeds (*Polygonum* spp.) were important in all five wetlands. Woody species, including boxelder (*Acer negundo*), winged elm (*Ulmus alata*), and honeylocust (*Gleditsia triacanthos*) were present on the margins of many of the wetlands.

**Most Abundant Species:**

No quantitative data

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**Mapped Type Name: Orchardgrass-Timothy-Fescue species-Goldenrod species  
Herbaceous Vegetation**

**Macrogroup:** M123. Eastern North American Ruderal Shrubland & Grassland

**Group:** G059. Northern & Central Ruderal Meadow & Shrubland Group

**Association:** CEGL006107

**Type Common Name:** Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation

**Type Scientific Name:** *Dactylis glomerata-Phleum pratense-Festuca* spp.-*Solidago* spp.  
Herbaceous Vegetation



**Figure 10.** Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation at Hopewell Culture National Historical Park

**Global Summary:** This group circumscribes a wide variety of shrub or herb meadows in the northern and central regions of the eastern United States. Introduced grasses that have been planted or volunteer into old fields dominate this type, typically with goldenrod species (*Solidago* spp.) as major components (Figure 10). Shrubs may or may not be present, and generally account for less than 25% of the total cover. Common shrubs include dogwood species (*Cornus* spp.), sumac species (*Rhus* spp.), blackberries (*Rubus* spp.), and eastern redcedar (*Juniperus virginiana*). Non-native shrubs commonly include multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonicas*), and Russian olive (*Elaeagnus angustifolia*).

**Environmental Description:** At HOCU, this type occurred on former croplands, generally in fairly flat, moist river floodplain or terrace soils.

**Vegetation Description:** This type was represented on all units within the park and tended to dominate view sheds. Orchardgrass (*Dactylis glomerata*) was the most common dominant, followed by Canada goldenrod (*Solidago canadensis*), meadow fescue (*Schedonorus pratensis*), timothy (*Phleum pratense*), and black medick (*Medicago lupulina*). These species are all typical

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of moist old fields in the eastern United States. Woody species were limited to shrubs and small trees, including Amur honeysuckle (*Lonicera maackii*), black cherry (*Prunus serotina*), and American elm (*Ulmus americana*), and these made up little of the cover (Table 6).

**Most Abundant Species:**

**Table 6.** Species found within two or more of five plots taken within the Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation type.

Orchardgrass-Timothy-Fescue species-Goldenrod species Herbaceous Vegetation			
Scientific Name	Common Name	Frequency	%Cover
Shrub Layer			
<i>Lonicera maackii</i>	Amur honeysuckle	40%	0.50
<i>Parthenocissus quinquefolia</i>	Virginia creeper	40%	0.50
<i>Prunus serotina</i>	black cherry	40%	0.50
<i>Ulmus americana</i>	American elm	40%	0.50
<i>Vitis vulpina</i>	frost grape	60%	0.50
Herbaceous Layer			
<i>Barbarea vulgaris</i>	garden yellowrocket	40%	0.50
<i>Cirsium</i> spp.	thistle	60%	0.50
<i>Conyza canadensis</i>	Canadian horseweed	40%	0.50
<i>Cynanchum laeve</i>	honeyvine	40%	0.50
<i>Dactylis glomerata</i>	orchardgrass	80%	52.63
<i>Erigeron strigosus</i>	prairie fleabane	80%	0.50
<i>Galium concinnum</i>	shining bedstraw	40%	0.50
<i>Ipomoea pandurata</i>	man of the earth	40%	0.50
<i>Medicago lupulina</i>	black medick	40%	9.00
<i>Phleum pratense</i>	timothy	40%	7.75
<i>Plantago rugelii</i>	blackseed plantain	40%	0.50
<i>Poa pratensis</i>	Kentucky bluegrass	60%	1.33
<i>Rubus pensilvanicus</i>	Pennsylvania blackberry	40%	0.50
<i>Rumex crispus</i>	curly dock	40%	0.50
<i>Schedonorus pratensis</i>	meadow fescue	60%	26.00
<i>Solidago canadensis</i>	Canada goldenrod	60%	45.83
<i>Taraxacum officinale</i>	common dandelion	40%	0.50
<i>Trifolium pratense</i>	red clover	60%	1.33

**Mapped Type Name: Restored Tallgrass Prairie**

**Macrogroup:** None

**Group:** None

**Association:** None

**Type Common Name:** Restored Tallgrass Prairie

**Type Scientific Name:** *Andropogon gerardii* Herbaceous Vegetation



**Figure 11.** Restored Tallgrass Prairie at Hopewell Culture National Historical Park.

**Global Summary:** Tallgrass prairie restorations have been attempted throughout the former tallgrass prairie region. The restoration at HOCU is typical of these efforts (Figure 11). Some combination of big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) are typically dominant in restorations. Both native and non-native grasses and forbs tend to volunteer into areas that have been planted with prairie grasses and forbs. Typically, grasses dominate these sites with a limited complement of native prairie forbs. Culms of dominant grasses reach more than 6 feet (2 meters) in the fall, and provide a prairie-like aspect. On-going efforts are required to maintain and enhance prairie restorations, both to reduce unwanted species and enhance the compliment of native prairie forbs and grasses.

**Environmental Description:** At HOCU, the prairie restoration occurred on soils that were relatively poorly drained, and in an area that is at the eastern edge of the tallgrass prairie region. The area was a single small patch in the southwest corner of the Hopewell Mount unit.

**Vegetation Description:** The prairie restoration was imbedded within the Orchardgrass - Timothy – Fescue spp. – Goldenrod spp. Herbaceous Vegetation, but was clearly distinguishable when the flowering culms of big bluestem (*Andropogon gerardii*) and other native grasses were visible in the fall. Big bluestem and Canada goldenrod (*Solidago canadensis*) were the prevailing, and often overwhelming, dominant species. Other important species included sideoats grama (*Bouteloua curtipendula*), blackeyed and browneyed Susan (*Rudbeckia hirta* and *Rudbeckia triloba*), wild bergamont (*Monarda fistulosa*), and stiff goldenrod (*Oligoneuron rigidum*). Shrubs and small trees included Pennsylvania blackberry (*Rubus pensilvanicus*),

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American elm (*Ulmus americana*), multiflora rose (*Rosa multiflora*), and slippery elm (*Ulmus rubra*) (Table 7).

**Most Abundant Species:**

**Table 7.** All species that occurred in one or both plots representing the Restored Tallgrass Prairie vegetation type.

Restored Tallgrass Prairie			
Scientific Name	Common Name	Frequency	%Cover
Shrub Layer			
<i>Rosa multiflora</i>	multiflora rose	50%	0.50
<i>Rubus pensilvanicus</i>	Pennsylvania blackberry	100%	0.50
<i>Toxicodendron radicans</i>	eastern poison ivy	50%	0.50
<i>Ulmus americana</i>	American elm	100%	0.50
<i>Ulmus rubra</i>	slippery elm	50%	0.50
<i>Vitis vulpina</i>	frost grape	100%	0.50
Herbaceous Layer			
<i>Achillea millefolium</i>	common yarrow	50%	0.50
<i>Allium</i> spp.	onion	50%	0.50
<i>Ambrosia artemisiifolia</i>	annual ragweed	50%	0.50
<i>Andropogon gerardii</i>	big bluestem	100%	26.25
<i>Bouteloua curtipendula</i>	sideoats grama	100%	1.75
<i>Bromus tectorum</i>	cheatgrass	100%	0.50
<i>Cynanchum laeve</i>	honeysuckle	50%	0.50
<i>Daucus carota</i>	Queen Anne's lace	50%	0.50
<i>Echinacea purpurea</i>	eastern purple coneflower	50%	0.50
<i>Erigeron strigosus</i>	prairie fleabane	100%	0.50
<i>Galium concinnum</i>	shining bedstraw	100%	0.50
<i>Ipomoea pandurata</i>	man of the earth	50%	0.50
<i>Medicago lupulina</i>	black medick	100%	3.00
<i>Melilotus officinalis</i>	sweetclover	50%	0.50
<i>Monarda fistulosa</i>	wild bergamot	100%	0.50
<i>Oligoneuron rigidum</i>	stiff goldenrod	100%	0.50
<i>Penstemon digitalis</i>	foxglove beardtongue	50%	0.50
<i>Rudbeckia hirta</i>	blackeyed Susan	50%	0.50
<i>Rudbeckia triloba</i>	browneyed Susan	100%	0.50
<i>Schedonorus pratensis</i>	meadow fescue	100%	0.50
<i>Solanum carolinense</i>	Carolina horsenettle	100%	0.50
<i>Solidago canadensis</i>	Canada goldenrod	100%	50.00
<i>Solidago ulmifolia</i>	elmleaf goldenrod	100%	0.50
<i>Sorghum halepense</i>	Johnsongrass	50%	0.50
<i>Taraxacum officinale</i>	common dandelion	50%	0.50
<i>Torilis arvensis</i>	field pennycress	50%	0.50

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<b>Restored Tallgrass Prairie</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Frequency</b>	<b>%Cover</b>
<i>Trifolium pratense</i>	red clover	50%	0.50
<i>Triosteum perfoliatum</i>	feverwort	50%	0.50

**Mapped Type Name: Ruderal Low Woodland/Shrubland**

**Macrogroup:** M013. Eastern North American Ruderal Forest & Plantation  
**Group:** G030. Northern & Central Hardwood & Conifer Ruderal Forest Group  
**Association:** None listed  
**Type Common Name:** Ruderal Low Woodland/Shrubland  
**Type Scientific Name:** *Elaeagnus umbellata*-*Gleditsia triacanthos* / *Rubus pensilvanica*  
Woodland/Shrubland



**Figure 12.** Ruderal Low Woodland/Shrubland at Hopewell Culture National Historical Park.

Global Summary: This group includes communities that show evidence of heavy human use (clearing, plowing) in the past. Woody species volunteer into these cleared areas more or less spontaneously, and vegetation is dominated (>80% cover) by ruderal or exotic species (Figure 12). A wide variety of woody species may be present, and these species may occur as monodominant or mixed stands. Some typical woody dominants include eastern redcedar (*Juniperus virginiana*), pines (*Pinus* spp.), hawthorns (*Crataegus* spp.), red maple (*Acer rubrum*), honey locust (*Gleditsia triacanthos*), and black walnut (*Juglans nigra*). Other associated shrubs and herbaceous species are generalist or ruderal species.

Environmental Description: At HOCU, this type occurred on a variety of soil types and land positions, but the largest portion was on rolling uplands at the Hopewell Mound Group unit. Soils were generally moist but well-grained.

Vegetation Description: This type was characterized by a patchy canopy of small trees and shrubs with weedy species dominating. Honeylocust (*Gleditsia triacanthos*) was the most

important tree species, followed by black cherry (*Prunus serotina*) and white ash (*Fraxinus americana*). Autumn olive (*Elaeagnus umbellata*) was present in all plots with fairly high cover, while hawthorns (*Crataegus* spp.) were dominant in patches (three of five plots). Vines, including Japanese honeysuckle (*Lonicera japonica*), Virginia creeper (*Parthenocissus quinquefolia*), eastern poison ivy (*Toxicodendron radicans*), and frost grape (*Vitis vulpina*) were common important species. Pennsylvania blackberry (*Rubus pensilvanicus*) and multiflora rose (*Rosa multiflora*), two thorny species, were important. Important herbaceous species included white snakeroot (*Ageratina altissima*), western panicgrass (*Dichanthelium acuminatum*), fragrant bedstraw (*Galium triflorum*), oxeye daisy (*Leucanthemum vulgare*), Canada goldenrod (*Solidago canadensis*), meadow fescue (*Schedonorus pratensis*), and Kentucky bluegrass (*Poa pratensis*) (Table 8).

**Most Abundant Species:**

**Table 8.** Species that occurred in at least two of five plots representing the Ruderal Low Woodland/Shrubland vegetation type.

Ruderal Low Woodland/Shrubland			
Scientific Name	Common Name	Frequency	%Cover
Tree Layer			
<i>Fraxinus americana</i>	white ash	40%	9.00
<i>Gleditsia triacanthos</i>	honeylocust	60%	18.50
<i>Prunus serotina</i>	black cherry	60%	7.00
Shrub Layer			
<i>Crataegus</i> spp.	hawthorn	60%	22.50
<i>Elaeagnus umbellata</i>	autumn olive	100%	14.70
<i>Fraxinus americana</i>	white ash	80%	1.75
<i>Gleditsia triacanthos</i>	honeylocust	100%	1.5
<i>Lonicera japonica</i>	Japanese honeysuckle	100%	14.70
<i>Lonicera maackii</i>	Amur honeysuckle	60%	0.50
<i>Parthenocissus quinquefolia</i>	Virginia creeper	100%	1.00
<i>Prunus serotina</i>	black cherry	60%	0.5
<i>Rosa multiflora</i>	multiflora rose	80%	6.00
<i>Rubus pensilvanicus</i>	Pennsylvania blackberry	100%	8.40
<i>Toxicodendron radicans</i>	eastern poison ivy	80%	10.38
<i>Ulmus americana</i>	American elm	40%	1.75
<i>Vitis vulpina</i>	frost grape	80%	1.13
Herbaceous Layer			
<i>Achillea millefolium</i>	common yarrow	100%	0.50
<i>Ageratina altissima</i>	white snakeroot	80%	4.13
<i>Agrimonia parviflora</i>	harvestlice	80%	0.50
<i>Apocynum cannabinum</i>	Indianhemp	40%	0.50
<i>Barbarea vulgaris</i>	garden yellowrocket	60%	0.50
<i>Bidens</i> spp.	beggarticks	40%	0.50
<i>Carex blanda</i>	eastern woodland sedge	80%	0.50

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<b>Ruderal Low Woodland/Shrubland</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Frequency</b>	<b>%Cover</b>
<i>Carex hirsutella</i>	fuzzy wuzzy sedge	40%	0.50
<i>Celastrus scandens</i>	American bittersweet	40%	0.50
<i>Circaea lutetiana</i>	broadleaf enchanter's nightshade	40%	0.50
<i>Cirsium</i> spp.	thistle	60%	0.50
<i>Daucus carota</i>	Queen Anne's lace	80%	0.50
<i>Dianthus armeria</i>	Deptford pink	40%	0.50
<i>Dichanthelium acuminatum</i>	western panicgrass	100%	1.00
<i>Dichanthelium latifolium</i>	broadleaf rosette grass	40%	1.75
<i>Erigeron strigosus</i>	prairie fleabane	60%	0.50
<i>Galium aparine</i>	stickywilly	40%	0.50
<i>Galium triflorum</i>	fragrant bedstraw	100%	0.50
<i>Geum vernum</i>	spring avens	60%	0.50
<i>Glechoma hederacea</i>	ground ivy	40%	0.50
<i>Juncus interior</i>	inland rush	40%	0.50
<i>Lactuca canadensis</i>	Canada lettuce	40%	0.50
<i>Leucanthemum vulgare</i>	oxeye daisy	100%	0.50
<i>Lobelia spicata</i>	palespike lobelia	60%	0.50
<i>Oxalis stricta</i>	common yellow oxalis	40%	0.50
<i>Poa pratensis</i>	Kentucky bluegrass	80%	2.38
<i>Potentilla simplex</i>	common cinquefoil	40%	0.50
<i>Prunella vulgaris</i>	common selfheal	60%	0.50
<i>Sanicula canadensis</i>	Canadian blacksnakeroot	80%	0.50
<i>Schedonorus pratensis</i>	meadow fescue	80%	4.75
<i>Solanum carolinense</i>	Carolina horsenettle	40%	0.50
<i>Solidago canadensis</i>	Canada goldenrod	80%	25.25
<i>Solidago ulmifolia</i>	elmleaf goldenrod	60%	0.50
<i>Symphyotrichum lateriflorum</i>	calico aster	60%	5.33
<i>Trifolium pratense</i>	red clover	40%	0.50
<i>Verbesina alternifolia</i>	wingstem	80%	1.75
<i>Viola sororia</i>	common blue violet	100%	3.40

**Mapped Type Name: Ruderal Woodland**

**Macrogroup:** M013. Eastern North American Ruderal Forest & Plantation  
**Group:** G030. Northern & Central Hardwood & Conifer Ruderal Forest Group  
**Association:** None listed (similar to CEGL004693)  
**Type Common Name:** Ruderal Woodland  
**Type Scientific Name:** *Juglans nigra-Celtis occidentalis* Forest



**Figure 13.** Ruderal Woodland at Hopewell Culture National Historical Park.

Global Summary: This group includes communities that show evidence of heavy human use (clearing, plowing) in the past. Woody species volunteer into these cleared areas more or less spontaneously, and vegetation is dominated (>80% cover) by ruderal or exotic species. A wide variety of woody species may be present, and these species occur as monodominant or mixed stands (Figure 13). Some typical woody dominates include eastern redcedar (*Juniperus virginiana*), pines (*Pinus* spp.), hawthorns (*Crataegus* spp.), red maple (*Acer rubrum*), honey locust (*Gleditsia triacanthos*), and black walnut (*Juglans nigra*). Other associated shrubs and herbaceous species are generalist or ruderal species.

Environmental Description: At HOCU, this type occurred in a variety of soils and land positions in all units except Seip Earthworks. The largest patch was at the Hopewell Mound Group unit, where it occurred on rolling uplands.

Vegetation Description: This type was represented by a variety of individual mapped patches with slightly different compositions. The general aspect of these communities represented rather open, low, young woodlands, but the canopy was closed in some places. Dominant trees included common hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), sugar maple (*Acer saccharum*), and black locust (*Robinia pseudoacacia*). The shrub layer varied across mapped patches, and important species included sugar maple, common hackberry, Amur

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honeysuckle (*Lonicera maackii*), multiflora rose (*Rosa multiflora*), and slippery elm (*Ulmus rubra*). Common forbs included white snake root (*Ageratina altissima*), garlic mustard (*Alliaria petiolata*), hairy wildrye (*Elymus villosus*), and Virginia wildrye (*Elymus virginicus*)(Table 9).

**Most Abundant Species:**

**Table 9.** Species that occurred in at least four of ten plots sampled within the Ruderal Woodland vegetation type.

Ruderal Woodland			
Scientific Name	Common Name	Frequency	%Cover
Tree Layer			
<i>Acer saccharum</i>	sugar maple	60%	22.25
<i>Celtis occidentalis</i>	common hackberry	70%	15.93
<i>Juglans nigra</i>	black walnut	50%	40.60
<i>Robinia pseudoacacia</i>	black locust	40%	8.38
Shrub Layer			
<i>Acer negundo</i>	boxelder	40%	5.38
<i>Acer saccharum</i>	sugar maple	50%	14.70
<i>Aesculus glabra</i>	Ohio buckeye	50%	1.50
<i>Asimina triloba</i>	pawpaw	30%	1.33
<i>Campsis radicans</i>	trumpet creeper	30%	0.50
<i>Celtis occidentalis</i>	common hackberry	30%	3.33
<i>Gleditsia triacanthos</i>	honeylocust	30%	0.50
<i>Juglans nigra</i>	black walnut	30%	0.50
<i>Lonicera japonica</i>	Japanese honeysuckle	60%	14.75
<i>Lonicera maackii</i>	Amur honeysuckle	90%	30.67
<i>Parthenocissus quinquefolia</i>	Virginia creeper	80%	7.56
<i>Prunus serotina</i>	black cherry	40%	1.13
<i>Rosa multiflora</i>	multiflora rose	50%	11.80
<i>Rubus occidentalis</i>	black raspberry	40%	1.13
<i>Toxicodendron radicans</i>	eastern poison ivy	30%	0.50
<i>Ulmus americana</i>	American elm	30%	2.17
<i>Ulmus rubra</i>	slippery elm	40%	5.38
Herbaceous Layer			
<i>Ageratina altissima</i>	white snakeroot	90%	0.50
<i>Alliaria petiolata</i>	garlic mustard	100%	4.40
<i>Carex blanda</i>	eastern woodland sedge	40%	0.50
<i>Elymus villosus</i>	hairy wildrye	70%	3.64
<i>Elymus virginicus</i>	Virginia wildrye	70%	13.50
<i>Festuca subverticillata</i>	nodding fescue	40%	17.63

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<b>Ruderal Woodland</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Frequency</b>	<b>%Cover</b>
<i>Fraxinus americana</i>	white ash	60%	7.88
<i>Galium aparine</i>	stickywilly	40%	1.13
<i>Galium triflorum</i>	fragrant bedstraw	30%	2.17
<i>Geum canadense</i>	white avens	70%	0.86
<i>Geum vernum</i>	spring avens	40%	1.13
<i>Hackelia virginiana</i>	beggarslice	40%	0.50
<i>Osmorhiza claytonii</i>	Clayton's sweetroot	70%	0.50
<i>Poa pratensis</i>	Kentucky bluegrass	30%	0.50
<i>Polygonum virginianum</i>	jumpseed	30%	0.50
<i>Polymnia canadensis</i>	whiteflower leafcup	50%	0.50
<i>Sanicula canadensis</i>	Canadian blacksnakeroot	30%	1.33
<i>Sanicula odorata</i>	clustered blacksnakeroot	50%	3.90
<i>Symphotrichum cordifolium</i>	common blue wood aster	50%	0.50
<i>Symphotrichum lateriflorum</i>	calico aster	40%	0.50
<i>Verbesina alternifolia</i>	wingstem	60%	33.92
<i>Viola sororia</i>	common blue violet	40%	5.38

**Mapped Type Name: Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest Group**

**Macrogroup:** M029. Northern & Central Floodplain Forest & Scrub

**Group:** NG040 Silver Maple-Green Ash-Sycamore Group

**Association:** None

**Type Common Name:** Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest Group

**Type Scientific Name:** *Acer saccharinum*-*Fraxinus pennsylvanica*-*Platanus occidentalis*-*Celtis* spp. Floodplain Forest Group



**Figure 14.** Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest Group at Hopewell Culture National Historical Park.

**Global Summary:** This group circumscribes a variety of floodplain forests of eastern North America. These communities are generally dominated by some combination of silver maple (*Acer saccharinum*), sycamore (*Platanus occidentalis*), hackberry species (*Celtis* spp.), American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*) (Figure 14). Vines, including eastern poison ivy (*Toxicodendron radicans*) and creepers (*Parthenocissus* spp.) are often abundant. Most areas are under water for some period each spring, and microtopography is important for defining water regimes on a local scale

**Environmental Description:** At HOCU, this type occurred in small, linear patches on floodplains along streams at the Seip Earthworks, High Bank Works, and Mound City Group units. Width of the floodplains varied between and among sites, and ranged from about 110 feet (33.5 meters) or less wide at Mound City to about 500 feet (152 meters) or less wide at Seip and High Bank.

**Vegetation Description:** Representative patches of this type were generally forests with an open understory and typical floodplain microtopography. Dominant species included common hackberry (*Celtis occidentalis*), American sycamore (*Platanus occidentalis*), silver maple (*Acer*

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*saccharinum*), and boxelder (*Acer negundo*). Boxelder and common hackberry were also important in the shrub layer, along with Ohio buckeye (*Aesculus glabra*) and Amur honeysuckle (*Lonicera maackii*). Vines were common, including eastern poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and frost grape (*Vitis vulpina*). Common herbaceous species included white snakeroot (*Ageratina altissima*), garlic mustard (*Alliaria petiolata*), Virginia wildrye (*Elymus virginicus*), Canadian woodnettle (*Laportea canadensis*), and clustered blacksnakeroot (*Sanicula odorata*) (Table 10).

**Most Abundant Species:**

**Table 10.** Species that occurred in at least two of ten plots sampled within the Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest Group vegetation type.

Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest Group			
Scientific Name	Common Name	Frequency	%Cover
Tree Layer			
<i>Acer negundo</i>	boxelder	80%	14.625
<i>Acer saccharinum</i>	silver maple	60%	22.5
<i>Celtis occidentalis</i>	common hackberry	80%	38.125
<i>Platanus occidentalis</i>	American sycamore	60%	22.50
Shrub Layer			
<i>Acer negundo</i>	boxelder	100%	3.9
<i>Aesculus glabra</i>	Ohio buckeye	60%	3.00
<i>Celtis occidentalis</i>	common hackberry	80%	39.98
<i>Campsis radicans</i>	trumpet creeper	40%	0.50
<i>Lonicera maackii</i>	Amur honeysuckle	100%	2.00
<i>Parthenocissus quinquefolia</i>	Virginia creeper	40%	0.50
<i>Toxicodendron radicans</i>	eastern poison ivy	100%	7.90
<i>Ulmus americana</i>	American elm	40%	1.75
<i>Vitis vulpina</i>	frost grape	40%	0.50
Herbaceous Layer			
<i>Ageratina altissima</i>	white snakeroot	100%	1.50
<i>Alliaria petiolata</i>	garlic mustard	100%	11.80
<i>Carex grayi</i>	Gray's sedge	40%	0.50
<i>Cryptotaenia canadensis</i>	Canadian honewort	80%	1.13
<i>Elymus virginicus</i>	Virginia wildrye	100%	14.20
<i>Galium aparine</i>	stickywilly	60%	0.50
<i>Geum canadense</i>	white avens	40%	0.50
<i>Hydrophyllum canadense</i>	bluntleaf waterleaf	40%	1.75
<i>Impatiens spp.</i>	touch-me-not	60%	0.50
<i>Laportea canadensis</i>	Canadian woodnettle	100%	55.10
<i>Leersia virginica</i>	whitegrass	60%	1.33

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<b>Silver Maple-Green Ash-Sycamore-Hackberry Floodplain Forest Group</b>			
<b>Scientific Name</b>	<b>Common Name</b>	<b>Frequency</b>	<b>%Cover</b>
<i>Phlox paniculata</i>	fall phlox	40%	0.50
<i>Polygonum virginianum</i>	jumpseed	60%	1.33
<i>Rudbeckia laciniata</i>	cutleaf coneflower	60%	0.50
<i>Sanicula odorata</i>	clustered blacksnakeroot	100%	6.80
<i>Smilax ecirrhata</i>	upright carrionflower	40%	0.50
<i>Verbesina alternifolia</i>	wingstem	80%	1.13
<i>Viola sororia</i>	common blue violet	40%	15.00
<i>Viola striata</i>	striped cream violet	80%	3.00



## **Discussion**

Hopewell Culture National Historical Park consisted of five units, most of which were dominated by ruderal grasslands on former croplands. Non-native meadows occurred on all units, and made up more than 70% of the non-developed area of the park. The most “semi-natural” and significant communities were (1) an upland limestone forest at the Hopewell Mound Group unit, (2) floodplain forests at the Seip Earthworks, High Bank Works, and Mound City Group units, and (3) a small prairie restoration on the Hopewell Mound Group unit. Ruderal shrublands and woodlands offer opportunities for restoration, especially at the Hopewell Mounds Group unit where they were continuous with a more mature forest. Ruderal grasslands offer opportunities for restoration to prairie.

### **Field Survey**

The plant communities of HOCU will be quite dynamic over time because many are relatively early successional types. Without management efforts, the ruderal grasslands will quickly become ruderal woodlands via succession. Documentation of change via repeated sampling, especially in maturing woodlands and forests, would be highly desirable. Sampling of the general landscape around the park units (e.g. interpretation of general vegetation types such as urban, grassland, and woodland/forest) would help to document context and provide early signs of urban encroachment on the boundaries, should that occur.

### **NVC Classification**

Quantitative data from the park may help in the description of ruderal vegetation types for the Midwest. Currently, no type descriptions that correspond with the ruderal woodlands, shrubland/woodland, or the floodplain forests exist. Some of these types are quite likely widespread on the landscape. Documentation of the composition of the ruderal woodland and shrubland/woodland may prove important as these types of habitats, though perhaps not uncommon, may not cover much area in the landscape, and do provide significant habitat to native fauna.

### **Digital Imagery and Interpretation**

Both leaf-on and leaf-off imagery were available for the park and were used to develop map polygons. The use of leaf-on and leaf-off data helped ensure high quality results. Because the park was small, heads up digitizing was used to circumscribe polygons.

### **Accuracy Assessment**

The high degree of thematic accuracy was made possible in part by the five separate units which make up the park. In addition, overall accuracy benefited from knowledgeable park staff that was able to efficiently and effectively navigate among each distinct unit of the park. The overall accuracy assessment, as well as the accuracy assessment of each mapped class exceeded the 80% level required by the NPS Vegetation Mapping Inventory program. Field staff was able to visit all polygons and assess thematic accuracy of all seven mapped vegetation classes. For all vegetation map classes, the dichotomous key allowed for clear identification at the majority of points.

### **Future Recommendations**

The vegetation at HOCU consists predominantly of open, ruderal grasslands. Efforts to restore these open habitats to a more natural state by restoring native prairie grasses and forbs seem appropriate. A number of woody species are invading these open habitats, and they will quickly become ruderal woodlands without active management. Tallgrass habitats are not common in the region, and restored grasslands at HOCU could be significant natural resources. The Appalachian Sugar Maple-Chinkapin Oak Limestone Forest on the Hopewell Mound Group unit represents the most “natural” vegetation type mapped in the park, and is adjacent to ruderal woodland and shrubland/woodland communities. Efforts to restore the ruderal types, and enhance the existing forest, seem appropriate. Several non-native invasive species are common within these communities and deserve management attention, including Amur honeysuckle (*Lonicera maackii*), Japanese honeysuckle (*Lonicera japonica*), and multiflora rose (*Rosa multiflora*) (Young, et al. 2012).

### **Research Opportunities**

Management activities that aim to restore ruderal grasslands and woodlands, and to control non-native invasive species, offer research opportunities at HOCU. The relatively large areas of ruderal grassland offer opportunities for monitoring of large-scale restoration efforts. Fire might not be a desired management tool for grassland restoration at HOCU, and if this is the case, novel approaches might need to be used. Hence, application of these novel approaches might offer research opportunities.

## Literature Cited

- Daubenmire, R.F. 1959. Canopy coverage method of vegetation analysis. *Northwest Science* 33:43-64
- Federal Geographic Data Committee (FGDC). 1998. Spatial data transfer standard, FGDC-STD-002 (modified version ANSI NCITS 20:1998). Available at <http://www.fgdc.gov/standards/>.
- Federal Geographic Data Committee. 2008. National vegetation classification standards. FGDC-STD-005-2008. Available at <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation/index.html>.
- Grossman D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, and others. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I, The National Vegetation Classification System: development, status, and applications. The Nature Conservancy: Arlington, VA. Available at <http://www.natureserve.org/publications/library.jsp#nspubs>.
- Jennings, M. D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet, and D. Roberts. 2009. Standards for Associations and alliances of the U.S. National Vegetation Classification. *Ecological Monographs* 79:173-199.
- Lance, G. N. and W. T. Williams. 1967. A general theory of classificatory sorting strategies, I. Hierarchical Systems. *The Computer Journal*. 9: 373-380.
- Lea, C. 2011. Vegetation classification guidelines: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/NRPC/NRR-2011/374. National Park Service, Fort Collins, Colorado.
- Lea, C., and A. C. Curtis. 2010. Thematic accuracy assessment procedures: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/2010/NRR—2010/204. National Park Service, Fort Collins, Colorado.
- Legendre, P., and L. Legendre. 1998. *Numerical Ecology*. 2<sup>nd</sup> English Edition. Elsevier Science B. V., Amsterdam. 853 pp.
- Maechler, M., P. Rousseeuw, A. Struyf, M. Hubert, and K. Hornik. 2011. cluster: Cluster Analysis Basics and Extensions. R package version 1.14.1. <http://CRAN.R-project.org/package=cluster>
- National Park Service. 2011. 12-step guidance for NPS vegetation inventories. Available at [http://science.nature.nps.gov/im/inventory/veg/docs/Veg\\_Inv\\_12step\\_Guidance\\_v1.1.pdf](http://science.nature.nps.gov/im/inventory/veg/docs/Veg_Inv_12step_Guidance_v1.1.pdf).
- National Park Service. 2011a. NPS vegetation inventory program final product specifications. Guidelines for creating final products. Available at [http://science.nature.nps.gov/im/inventory/veg/docs/Product\\_Specifications.pdf](http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf)

Natureserve. 2013. NatureServe Web Service. Arlington, VA. U.S.A.  
Available <http://services.natureserve.org>.

Roberts, D. W. 2010. labdsv: Ordination and Multivariate Analysis for Ecology. R package version 1.4-1. <http://CRAN.R-project.org/package=labdsv>

The Nature Conservancy (TNC) and Environmental Systems Research Institute (ESRI). 1994. NBS/NPS Vegetation Mapping Program: Standardized National Vegetation Classification System. Prepared for the U.S. Department of the Interior, National Biological Survey and National Park Service. Washington, D.C.

The Nature Conservancy (TNC). 1996. Methodology for Assessing the Utility of Existing Data for Vegetation Mapping. Arlington, VA.

Thornberry-Ehrlich, T. L. 2013. Hopewell Culture National Historic Park: geologic resources inventory report. Natural Resource Report NPS/NRSS/GRD/NRR-2013/640. National Park Service, Fort Collins, Colorado.

USDA, and NRCS. 2009. The PLANTS Database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Available at <http://plants.usda.gov/java/>.

U.S. Geological Survey (USGS). 1999. Map accuracy standards. Fact sheet FS-171-99 (November 1999). Web address: <http://nationalmap.gov/standards/nmas.html>.

Young, C. C, J. C. Bell, C. S. Gross, and A. D. Dunkle. 2012. Invasive exotic plant monitoring at Hopewell Culture National Historic Park: Year 2 (2011). Natural Resource Data Series NPS/HTLN/NRDS—2012/346. National Park Service, Fort Collins, Colorado.

## Appendix A: Contingency Table for Vegetation Mapping at Hopewell Culture National Historical Site

		Reference Data (Accuracy Assessment Field Data)							User's Error			
Sample Data (Polygon Map Data)	Map Units	Appalachian Sugar Maple - Chinkapin Oak Limestone Forest	Orchardgrass - Timothy - Fescue species - Goldenrod species Herbaceous Vegetation	Restored Tallgrass Prairie	Ruderal Woodland	Ruderal Woodland/Shrubland	Silver Maple - Green Ash - Sycamore - Hackberry Floodplain Forest Group	Eastern North American Wet Meadow Group	Totals	Commission Accuracy	90% Conf. interval	
											-	+
		Appalachian Sugar Maple - Chinkapin Oak Limestone Forest	2						2	100.0%	75.0%	100.0%
		Orchardgrass - Timothy - Fescue species - Goldenrod species Herbaceous Vegetation		24					24	100.0%	97.9%	100.0%
		Restored Tallgrass Prairie			1				1	100.0%	50.0%	100.0%
		Ruderal Woodland				20	2		22	90.9%	78.6%	100.0%
		Ruderal Woodland/Shrubland					4		4	100.0%	87.5%	100.0%
		Silver Maple - Green Ash - Sycamore - Hackberry Floodplain Forest Group						4	4	100.0%	87.5%	100.0%
		Eastern North American Wet Meadow Group							4	100.0%	87.5%	100.0%
		Totals	2	24	1	20	6	4	4			
Producer's Error	Omission Accuracy	100.0%	100.0%	100.0%	100.0%	74.2%	100.0%	100.0%	<b>59 Total Correct Points</b>			
	90% Conf. -	100.0%	100.0%	100.0%	98.6%	74.1%	100.0%	100.0%	<b>61 Total Points</b>			
	Level +	100.0%	100.0%	100.0%	100.0%	74.4%	100.0%	100.0%				
<b>Overall Total Accuracy =98.5% Overall Kappa Index =93.2% Overall 90% Upper and Lower Confidence Interval =96.9% and 100.2%</b>												

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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), <u>large</u> (>10-100x plot), small (3-10x plot), <u>very small</u> (1-3x plot), unknown	
Representativeness	
Landform (circle) <u>interfluve</u> , gap/saddle, side slope, terrace/bench flat plain	
Topographic Position (circle) <u>crest</u> , upper slope, middle slope, lower slope, toe slope, <u>plain/level/bottom</u> , basin/depression	
Hydrologic Regime <u>Upland</u> Permanently flooded <u>Semipermanently</u> flooded <u>Seasonally/Temporarily flooded</u> Unknown	
Plot Shape (circle) <u>concave</u> convex flat irregular	
<u>General Comments</u>	
_____	
_____	
_____	







## Appendix C: Hopewell Culture National Historic Park Dichotomous Key to Mapped Current Vegetation Types

- 1a. Wetland with open water present or evidence of alternating wet and dry conditions; herbaceous species such as spikerushes (*Eleocharis* spp.), sedges (*Carex* spp.), and smartweed (*Polygonum* spp.) present ..... **Eastern North American Wet Meadow Group**
- 1b. Vegetation without herbaceous wetland species prominent ..... **2**
- 2a. Woodland or forest with overstory canopy cover (at a height > 4m) greater than 25% ..... **3**
- 3a. Woodland or forest on lowlands adjacent to creeks with combined cover of boxelder (*Acer negundo*), sliver maple (*Acer saccharinum*), eastern cottonwood (*Populus deltoides*), and common hackberry (*Celtis occidentalis*) greater than 50%. Canadian woodnettle (*Laportea canadensis*) and/or whitegrass (*Leersia virginica*) often common in the understory. .... **Silver Maple - Green Ash - Sycamore - Hackberry Floodplain Forest Group**
- 3b. Woodland or forest on uplands or slopes above lowlands ..... **4**
- 4a. Combined cover of sugar maple (*Acer saccharum*), hickories (*Carya* spp.), and oaks (*Quercus* spp.) greater than 35% and combined cover of common hackberry (*Celtis occidentalis*) and black walnut (*Juglans nigra*) less than 30%; with low (<10%) cover of bush honeysuckle (*Lonicera maackii* or *Lonicera tatarica*); and with herbaceous species such as mayapple (*Podophyllum peltatum*), great waterleaf (*Hydrophyllum appendiculatum*), touch-me-not (*Impatiens* spp.), and bristly greenbrier (*Smilax tamnoides*) commonly encountered. .... **Appalachian Sugar Maple – Chinkapin Oak Limestone Forest**
- 4b. Combined cover of sugar maple (*Acer saccharum*), hickories (*Carya* spp.), and oaks (*Quercus* spp.) less than 35% OR cover of bush honeysuckle (*Lonicera maackii* or *Lonicera tatarica*) greater than 10% ..... **Ruderal Woodland**
- 2b. Shrubland or grassland with overstory canopy cover (at a height of > 4 m) less than 25% .  
..... **5**
- 5a. Herbaceous vegetation with woody shrub and low tree cover < 25% ..... **6**
- 6a. Restored prairie with species such as big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), wild bergamot (*Monarda fistulosa*), stiff goldenrod (*Oligoneuron rigidum*), and browneyed Susan (*Rudbeckia triloba*) commonly encountered..... **Restored Tallgrass Prairie**
- 6b. Herbaceous vegetation lacking the above species and typically dominated by orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*), Canada goldenrod (*Solidago canadensis*) and/or meadow fescue (*Schedonorus pratensis*) ..... **Orchardgrass – Timothy – Fescue species – Goldenrod species Herbaceous Vegetation**
- 5b. Woody shrub and low tree cover > 25% ..... **Ruderal Low Woodland/Shrubland**



## Appendix D: Example of Accuracy Assessment Form

### Accuracy Assessment Form

#### NPS Vegetation Inventory

PLOT (WAYPOINT) #: \_\_\_\_\_ 2. DATE: \_\_\_\_\_

OBSERVER (DETERMINING ASSOCIATION) \_\_\_\_\_

Observer (assisting) \_\_\_\_\_

ACCURACY OF NAVIGATION (METERS) \_\_\_\_\_

How Determined: \_\_\_\_\_

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 Hopewell Culture National Historical Park

Family	Scientific Name	Common Name
<b>Acanthaceae</b>	<i>Ruellia strepens</i>	limestone wild petunia
<b>Aceraceae</b>	<i>Acer negundo</i>	boxelder
	<i>Acer saccharinum</i>	silver maple
	<i>Acer saccharum</i>	sugar maple
<b>Anacardiaceae</b>	<i>Toxicodendron radicans</i>	eastern poison ivy
<b>Annonaceae</b>	<i>Asimina triloba</i>	pawpaw
<b>Apiaceae</b>	<i>Cryptotaenia canadensis</i>	Canadian honewort
	<i>Daucus carota</i>	Queen Anne's lace
	<i>Ligusticum canadense</i>	Canadian licorice-root
	<i>Osmorhiza claytonii</i>	Clayton's sweetroot
	<i>Pastinaca sativa</i>	wild parsnip
	<i>Sanicula canadensis</i>	Canadian blacksnakeroot
	<i>Sanicula odorata</i>	clustered blacksnakeroot
	<i>Torilis arvensis</i>	spreading hedgeparsley
<b>Apocynaceae</b>	<i>Apocynum cannabinum</i>	Indianhemp
	<i>Vinca minor</i>	common periwinkle
<b>Araceae</b>	<i>Arisaema triphyllum</i>	Jack in the pulpit
<b>Aristolochiaceae</b>	<i>Aristolochia serpentaria</i>	Virginia snakeroot
	<i>Asarum canadense</i>	Canadian wildginger
<b>Asclepiadaceae</b>	<i>Asclepias syriaca</i>	common milkweed
	<i>Cynanchum laeve</i>	honeysuckle
<b>Aspleniaceae</b>	<i>Asplenium platyneuron</i>	ebony spleenwort
<b>Asteraceae</b>	<i>Achillea millefolium</i>	common yarrow
	<i>Ageratina altissima</i>	white snakeroot
	<i>Ambrosia artemisiifolia</i>	annual ragweed
	<i>Bidens</i>	beggarticks
	<i>Cirsium altissimum</i>	tall thistle
	<i>Conyza canadensis</i>	Canadian horseweed
	<i>Echinacea purpurea</i>	eastern purple coneflower
	<i>Erigeron philadelphicus</i>	Philadelphia fleabane
	<i>Erigeron strigosus</i>	prairie fleabane
	<i>Heliopsis helianthoides</i>	smooth oxeye
	<i>Lactuca canadensis</i>	Canada lettuce
	<i>Lactuca floridana</i>	woodland lettuce
	<i>Lactuca serriola</i>	prickly lettuce
	<i>Leucanthemum vulgare</i>	oxeye daisy
	<i>Oligoneuron rigidum</i> var. <i>rigidum</i>	stiff goldenrod

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<b>Family</b>	<b>Scientific Name</b>	<b>Common Name</b>
<b>Asteraceae</b>	<i>Packera obovata</i>	roundleaf ragwort
	<i>Polymnia canadensis</i>	whiteflower leafcup
	<i>Prenanthes alba</i>	white rattlesnakeroot
	<i>Rudbeckia hirta</i>	blackeyed Susan
	<i>Rudbeckia laciniata</i>	cutleaf coneflower
	<i>Rudbeckia triloba</i>	browneyed Susan
	<i>Solidago canadensis</i>	Canada goldenrod
	<i>Solidago ulmifolia</i>	elmleaf goldenrod
	<i>Symphyotrichum cordifolium</i>	common blue wood aster
	<i>Symphyotrichum lanceolatum</i>	white panicle aster
	<i>Symphyotrichum lateriflorum</i> var. <i>lateriflorum</i>	calico aster
	<i>Symphyotrichum shortii</i>	Short's aster
	<i>Taraxacum officinale</i>	common dandelion
	<i>Tragopogon dubius</i>	yellow salsify
	<i>Verbesina alternifolia</i>	wingstem
<i>Vernonia gigantea</i>	giant ironweed	
<b>Berberidaceae</b>	<i>Jeffersonia diphylla</i>	twinleaf
	<i>Podophyllum peltatum</i>	mayapple
<b>Betulaceae</b>	<i>Corylus americana</i>	American hazelnut
<b>Bignoniaceae</b>	<i>Campsis radicans</i>	trumpet creeper
<b>Boraginaceae</b>	<i>Hackelia virginiana</i>	beggarslice
	<i>Myosotis verna</i>	spring forget-me-not
<b>Brassicaceae</b>	<i>Alliaria petiolata</i>	garlic mustard
	<i>Arabis canadensis</i>	sicklepod
	<i>Arabis laevigata</i>	smooth rockcress
	<i>Barbarea vulgaris</i>	garden yellowrocket
	<i>Hesperis matronalis</i>	dames rocket
	<i>Thlaspi arvense</i>	field pennycress
<b>Campanulaceae</b>	<i>Campanulastrum americanum</i>	American bellflower
	<i>Lobelia spicata</i>	palespike lobelia
<b>Caprifoliaceae</b>	<i>Lonicera japonica</i>	Japanese honeysuckle
	<i>Lonicera maackii</i>	Amur honeysuckle
	<i>Lonicera tatarica</i>	Tatarian honeysuckle
	<i>Sambucus nigra</i> ssp. <i>canadensis</i>	American black elderberry
	<i>Symphoricarpos orbiculatus</i>	coralberry
	<i>Triosteum perfoliatum</i>	feverwort
	<i>Viburnum prunifolium</i>	blackhaw
	<i>Viburnum rufidulum</i>	rusty blackhaw
<b>Caryophyllaceae</b>	<i>Dianthus armeria</i>	Deptford pink

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<b>Family</b>	<b>Scientific Name</b>	<b>Common Name</b>
<b>Caryophyllaceae</b>	<i>Stellaria media</i>	common chickweed
<b>Celastraceae</b>	<i>Celastrus scandens</i>	American bittersweet
<b>Clusiaceae</b>	<i>Hypericum punctatum</i>	spotted St. Johnswort
<b>Convolvulaceae</b>	<i>Ipomoea pandurata</i>	man of the earth
<b>Cornaceae</b>	<i>Cornus florida</i>	flowering dogwood
<b>Cupressaceae</b>	<i>Juniperus virginiana</i>	eastern redcedar
<b>Cyperaceae</b>	<i>Carex</i>	sedge
	<i>Carex amphibola</i>	eastern narrowleaf sedge
	<i>Carex blanda</i>	eastern woodland sedge
	<i>Carex grayi</i>	Gray's sedge
	<i>Carex hirsutella</i>	fuzzy wuzzy sedge
	<i>Carex jamesii</i>	James' sedge
	<i>Carex muehlenbergii</i>	Muhlenberg's sedge
	<i>Carex nigromarginata</i>	black edge sedge
	<i>Carex retroflexa</i>	reflexed sedge
<b>Elaeagnaceae</b>	<i>Elaeagnus umbellata</i>	autumn olive
<b>Fabaceae</b>	<i>Amphicarpaea bracteata</i>	American hogpeanut
	<i>Cercis canadensis</i>	eastern redbud
	<i>Gleditsia triacanthos</i>	honeylocust
	<i>Medicago lupulina</i>	black medick
	<i>Medicago sativa</i>	alfalfa
	<i>Melilotus officinalis</i>	sweetclover
	<i>Robinia pseudoacacia</i>	black locust
	<i>Trifolium pratense</i>	red clover
<b>Fagaceae</b>	<i>Quercus alba</i>	white oak
	<i>Quercus muehlenbergii</i>	chinkapin oak
<b>Fumariaceae</b>	<i>Corydalis flavula</i>	yellow fumewort
<b>Geraniaceae</b>	<i>Geranium carolinianum</i>	Carolina geranium
	<i>Geranium maculatum</i>	spotted geranium
<b>Hippocastanaceae</b>	<i>Aesculus glabra</i>	Ohio buckeye
<b>Hydrophyllaceae</b>	<i>Hydrophyllum appendiculatum</i>	great waterleaf
	<i>Hydrophyllum canadense</i>	bluntleaf waterleaf
	<i>Phacelia purshii</i>	Miami mist
<b>Iridaceae</b>	<i>Sisyrinchium angustifolium</i>	narrowleaf blue-eyed grass
<b>Juglandaceae</b>	<i>Carya cordiformis</i>	bitternut hickory
	<i>Carya ovata</i>	shagbark hickory
	<i>Juglans nigra</i>	black walnut
<b>Juncaceae</b>	<i>Juncus interior</i>	inland rush
	<i>Juncus tenuis</i>	poverty rush
<b>Lamiaceae</b>	<i>Glechoma hederacea</i>	ground ivy

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<b>Family</b>	<b>Scientific Name</b>	<b>Common Name</b>
<b>Lamiaceae</b>	<i>Monarda fistulosa</i>	wild bergamot
	<i>Nepeta cataria</i>	catnip
	<i>Prunella vulgaris</i>	common selfheal
<b>Lauraceae</b>	<i>Lindera benzoin</i>	northern spicebush
	<i>Sassafras albidum</i>	sassafras
<b>Liliaceae</b>	<i>Allium tricoccum</i>	ramp
	<i>Hemerocallis fulva</i>	orange daylily
	<i>Maianthemum racemosum</i> ssp. <i>racemosum</i>	feathery false lily of the valley
	<i>Polygonatum biflorum</i>	smooth Solomon's seal
	<i>Trillium sessile</i>	toadshade
<b>Menispermaceae</b>	<i>Menispermum canadense</i>	common moonseed
<b>Moraceae</b>	<i>Maclura pomifera</i>	osage orange
	<i>Morus alba</i>	white mulberry
	<i>Morus rubra</i>	red mulberry
<b>Oleaceae</b>	<i>Fraxinus americana</i>	white ash
<b>Onagraceae</b>	<i>Circaea lutetiana</i> ssp. <i>canadensis</i>	broadleaf enchanter's nightshade
<b>Ophioglossaceae</b>	<i>Botrychium virginianum</i>	rattlesnake fern
<b>Oxalidaceae</b>	<i>Oxalis dillenii</i>	slender yellow woodsorrel
	<i>Oxalis stricta</i>	common yellow oxalis
<b>Papaveraceae</b>	<i>Sanguinaria canadensis</i>	bloodroot
<b>Passifloraceae</b>	<i>Passiflora lutea</i>	yellow passionflower
<b>Phytolaccaceae</b>	<i>Phytolacca americana</i>	American pokeweed
<b>Plantaginaceae</b>	<i>Plantago rugelii</i>	blackseed plantain
<b>Platanaceae</b>	<i>Platanus occidentalis</i>	American sycamore
<b>Poaceae</b>	<i>Agrostis gigantea</i>	redtop
	<i>Andropogon gerardii</i>	big bluestem
	<i>Bouteloua curtipendula</i>	sideoats grama
	<i>Bromus pubescens</i>	hairy woodland brome
	<i>Bromus tectorum</i>	cheatgrass
	<i>Dactylis glomerata</i>	orchardgrass
	<i>Dichanthelium acuminatum</i> var. <i>fasciculatum</i>	western panicgrass
	<i>Dichanthelium latifolium</i>	broadleaf rosette grass
	<i>Elymus villosus</i>	hairy wildrye
	<i>Elymus virginicus</i>	Virginia wildrye
	<i>Festuca subverticillata</i>	nodding fescue
	<i>Leersia virginica</i>	whitegrass
	<i>Phleum pratense</i>	timothy

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<b>Family</b>	<b>Scientific Name</b>	<b>Common Name</b>
<b>Poaceae</b>	<i>Poa pratensis</i>	Kentucky bluegrass
	<i>Poa sylvestris</i>	woodland bluegrass
	<i>Schedonorus pratensis</i>	meadow fescue
	<i>Sorghastrum nutans</i>	Indiangrass
	<i>Sorghum halepense</i>	Johnsongrass
	<i>Tridens flavus</i>	purpletop tridens
<b>Polemoniaceae</b>	<i>Phlox divaricata</i>	wild blue phlox
	<i>Phlox paniculata</i>	fall phlox
	<i>Polemonium reptans</i>	Greek valerian
<b>Polygonaceae</b>	<i>Polygonum scandens</i>	climbing false buckwheat
	<i>Polygonum virginianum</i>	jumpseed
	<i>Rumex crispus</i>	curly dock
<b>Primulaceae</b>	<i>Lysimachia nummularia</i>	creeping jenny
<b>Ranunculaceae</b>	<i>Clematis virginiana</i>	devil's darning needles
	<i>Hydrastis canadensis</i>	goldenseal
	<i>Thalictrum thalictroides</i>	rue anemone
<b>Rosaceae</b>	<i>Agrimonia parviflora</i>	harvestlice
	<i>Agrimonia pubescens</i>	soft agrimony
	<i>Agrimonia rostellata</i>	beaked agrimony
	<i>Crataegus</i>	hawthorn
	<i>Fragaria virginiana</i>	Virginia strawberry
	<i>Geum canadense</i>	white avens
	<i>Geum vernum</i>	spring avens
	<i>Malus coronaria</i>	sweet crab apple
	<i>Potentilla recta</i>	sulphur cinquefoil
	<i>Potentilla simplex</i>	common cinquefoil
	<i>Prunus americana</i>	American plum
	<i>Prunus serotina</i>	black cherry
	<i>Rosa multiflora</i>	multiflora rose
	<i>Rubus occidentalis</i>	black raspberry
<i>Rubus pensilvanicus</i>	Pennsylvania blackberry	
<b>Rubiaceae</b>	<i>Galium aparine</i>	stickywilly
	<i>Galium circaezans</i>	licorice bedstraw
	<i>Galium concinnum</i>	shining bedstraw
	<i>Galium triflorum</i>	fragrant bedstraw
<b>Salicaceae</b>	<i>Populus deltoides</i>	eastern cottonwood
<b>Scrophulariaceae</b>	<i>Penstemon digitalis</i>	foxglove beardtongue
	<i>Verbascum blattaria</i>	moth mullein
	<i>Verbascum thapsus</i>	common mullein
<b>Smilacaceae</b>	<i>Smilax ecirrhata</i>	upright carrionflower

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<b>Family</b>	<b>Scientific Name</b>	<b>Common Name</b>
<b>Smilacaceae</b>	<i>Smilax pulverulenta</i>	downy carrionflower
	<i>Smilax rotundifolia</i>	roundleaf greenbrier
	<i>Smilax tamnoides</i>	bristly greenbrier
<b>Solanaceae</b>	<i>Solanum carolinense</i>	Carolina horsenettle
<b>Ulmaceae</b>	<i>Celtis occidentalis</i>	common hackberry
	<i>Ulmus americana</i>	American elm
	<i>Ulmus rubra</i>	slippery elm
<b>Urticaceae</b>	<i>Laportea canadensis</i>	Canadian woodnettle
	<i>Pilea pumila</i>	Canadian clearweed
<b>Valerianaceae</b>	<i>Valerianella chenopodiifolia</i>	goosefoot cornsalad
<b>Verbenaceae</b>	<i>Phryma leptostachya</i>	American lopseed
	<i>Verbena urticifolia</i>	white vervain
<b>Violaceae</b>	<i>Viola sororia</i>	common blue violet
	<i>Viola striata</i>	striped cream violet
<b>Vitaceae</b>	<i>Parthenocissus quinquefolia</i>	Virginia creeper
	<i>Vitis vulpina</i>	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.

NPS 353/124362, April 2014

**National Park Service**  
**U.S. Department of the Interior**



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