U.S. Geological Survey-National Park Service Vegetation Mapping Program
Effigy Mounds National Monument, Iowa

Project Report

January 2005

U.S. Geological Survey-National Park Service Vegetation Mapping Program Effigy Mounds National Monument, Iowa

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This report produced by

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January 2005

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Suggested citation:

Hop, K., S. Lubinski, S. Menard. 2005. USGS-NPS Vegetation Mapping Program: Effigy Mounds National Monument, Iowa. U.S. Geolological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, January 2005. 62 pp + Appendixes A-I.

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Acknowledgements

This project required the cooperation and assistance of many individuals. The authors wish to acknowledge those individuals who have been essential in making this project a success.

National Park Service Effigy Mounds National Monument:

Phyllis Ewing for her excitement, encouragement, and support of this project.

Rodney Rovang for sharing his vast knowledge of the local area and helping us become acquainted with the ecological landscape.

The park's outstanding office and visitor center staff for helping us find our way around and providing us with gate keys and field equipment.

National Park Service Midwest Regional Office:

Peter Budde, Kathie Hanson, and Reese Hirth of the Midwest Regional Office for providing us with geospatial data and for assisting us in the development of the project boundary extent. And again, Peter Budde for providing us his expertise and guidance with metadata.

Lisa Thomas and Brian Witcher, formerly of the Prairie Cluster Long Term Ecological Monitoring Program, for their contribution to the scoping meeting, and for sharing their ecological and geospatial data collection experiences at EFMO.

U.S. Geological Survey Upper Midwest Environmental Sciences Center:

Janis Boyd for her devotion and successful application of state-of-the-art ortho rectifying software, bringing the photointerpreted map data into the geospatial forum, and for producing an excellent ortho mosaic of the project's aerial photographs.

Christine Calogero Lovelace for her help in collecting vegetation field data in all types of weather, for database entry and management of vegetation plot and accuracy assessment field data, and for her detailed approach in digitally automating a myriad of polygons and attributes, bringing once again the hard-copy map data to first class geospatial map coverages.

Mara May (formerly of UMESC) for her enduring devotion in the field during those long, hot, and humid Midwest summer days, and for setting up the accuracy assessment site selection. Brian Pruka (formerly of UMESC) for his invaluable assistance in vegetation sample collection, keying plants, and his brilliant ecological insights and perspectives.

Dan Fitzpatrick, Stephan Picault, Becki Rohweder (each formerly of UMESC), Erin Hoy, Jennie Sauer, Ken Lubinski, and Eric Seeger for coming to our aid as field assistants.

Melvin Bower, John C. (JC) Nelson, and the next generation of GIS gurus for their quality assurance and quality control of digital map automation products.

Iowa Natural Areas Inventory:

John Pearson for his perspective in ecological vegetation communities of the area.

NatureServe:

Jim Drake of the Minneapolis Office for providing invaluable guidance and assistance in vegetation sampling protocols, classification development, and PLOTS database management.

A large thanks to everyone involved. We extend our apologies to anyone we neglected to recognize.

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U.S. Geological Survey-National Park Service Vegetation Mapping Program Effigy Mounds National Monument, Iowa

by

Kevin Hop, Sara Lubinski, and Shannon Menard

Summary

The U.S. Geological Survey (USGS) is cooperating with the National Park Service (NPS) Natural Resource Inventory and Monitoring Program to classify, describe, and map vegetation of National Park units. This cooperative effort is known as the USGS-NPS Vegetation Mapping Program (VMP). The USGS Upper Midwest Environmental Sciences Center (UMESC) in La Crosse, Wisconsin, and the Minneapolis Office of NatureServe in Minneapolis, Minnesota, have completed mapping and classification of existing plant communities at Effigy Mounds National Monument (EFMO) and extended surroundings.

Photointerpreters, ecologists, and botanists collaborated to describe National Vegetation Classification System (NVCS) plant associations (communities) and determine how best to map them using aerial photographs. The team collected 63 vegetation plot samples for analysis, defining 15 NVCS plant communities. Two plant communities were added based on less formal sampling data, affirming 17 NVCS plant communities at EFMO. An additional 10 vegetation units were classed at the NVCS Formation level depicting human disturbance and cultivated lands.

Of 47 map classes developed for the mapping project, 30 represent the 17 NVCS plant communities. Plant communities, primarily forested types, were subdivided to provide resource managers and researchers information the plant community level could not provide. These map class phases typically define recurring variations within a plant community and suggest an index to disturbance history and integrity of the plant community. Another 9 map classes represent the 10 NVCS Formation level vegetation units, and an additional 8 map classes depict general land cover.

Two vegetation map coverages were produced, the Yellow River and Sny Magill Units and their respective environs. Vegetation and land use were interpreted using high-quality mirror stereoscopes and 1:8,000-scale color infrared aerial photographs dated October 9, 2000. Polygons were mapped to 0.25 ha (0.62 acres) and, for specific classes, to 0.1 ha (0.25 acres). The interpreted data were digitally and spatially referenced using state-of-the-art mapping software, making the map data usable in geographic information systems.

Covering 4,972 ha (12,286 acres), 2,844 polygons make up the 2 geospatial map coverages with an average polygon size of 1.7 ha (4.3 acres). Of the area mapped, 2,179 polygons (76.6%) represent NVCS plant communities as defined by NatureServe. Those polygons cover 3,167 ha (7,825 acres; 63.7%) of the

total map area. Another 529 polygons (18.6%) represent NVCS Formation level types covering 1,316 ha (3,251 acres; 26.5%) of the total map area. The remaining 136 polygons (4.8%) represent land use features covering 489 ha (1,208 acres; 9.8%). EFMO lands comprise 1,022 ha (2,526 acres; 20.6%) of the map coverage area. About 563 ha (1,390 acres; 11.3%) of the map coverage area is of Iowa's Yellow River State Forest.

Results from a thematic accuracy assessment of map classes representing NVCS plant communities provide an overall accuracy of 92% (Kappa index of 90%). Most individual map class themes exceed the VMP standard of 80% with a 90% confidence interval.

The EFMO project delivers many geospatial and vegetation data products in hard copy and digital formats. These products include an in-depth project summary report discussing methods and results and vegetation community descriptions and dichotomous key. They also include representative ground photos of plant community types, database sets of plot samples and accuracy assessment sites, field data sheets, aerial photograph prints and images (including geo-referenced photo mosaics), map classification and descriptions, and maps and spatial coverages of vegetation communities, fieldwork locations, aerial photo indexes, and project boundaries. All geospatial products are in Universal Transverse Mercator projection, Zone 15, using North American Datum of 1983. More VMP information and products of completed park mapping projects are on the Internet at <http://biology.usgs.gov/npsveg>.

Introduction

Effigy Mounds National Monument Vegetation Mapping Project

The Effigy Mounds National Monument (EFMO) Vegetation Mapping Project is an initiative of the U.S. Geological Survey (USGS)-National Park Service (NPS) Vegetation Mapping Program (VMP). The goals of the project are to adequately describe and map plant communities of EFMO and immediate surroundings and provide the NPS Inventory and Monitoring (I&M) Program, resource managers, and biological researchers with useful baseline vegetation information.

We successfully collected two sets of aerial photographs during summer and fall of 2000 and officially inaugurated the mapping project spring 2001 with a scoping meeting where partners discussed the project's objectives, goals, and methods. Major collaborators included the VMP coordinating offices [USGS Center for Biological Informatics (CBI) and NPS Natural Resources Information Division (NRID)], the NPS EFMO, the NatureServe Minneapolis Office, and the USGS Upper Midwest Environmental Sciences Center (UMESC).

Common to all VMP mapping projects, the three major components of the EFMO Vegetation Mapping Project are vegetation classification, vegetation mapping, and map accuracy assessment. In this report we discuss each of these fundamental components in detail.

The USGS-NPS Vegetation Mapping Program

The USGS-NPS VMP is a cooperative effort by the USGS and the NPS to classify, describe, and map existing plant communities in National Park units across the United States. The goal of the VMP is to meet specific information needs identified by the NPS. The VMP, managed by the USGS CBI and the NPS NRID, provides baseline vegetation information to the NPS I&M Program. Vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs. They also provide a structure for framing and answering critical scientific questions about vegetation communities and their relation to environmental processes across the landscape.

Vegetation Mapping Program scientists developed procedures for classification, mapping, and accuracy assessment (The Nature Conservancy [TNC] and Environmental Systems Research Institute [ESRI] 1994a, 1994b; TNC et al. 1994). Ecology and mapping teams worked together to share knowledge and data and resolve issues regarding classification and mapping procedures. The VMP products meet Federal Geographic Data Committee (FGDC) standards for vegetation classification and metadata and national standards for spatial accuracy and data transfer. Mapping standards include a minimum mapping unit (MMU) of 0.5 ha (1.2 acres) and classification accuracy meeting or exceeding 80% (with a 90% confidence level) for map classes representing plant communities. All geospatial products are in Universal Transverse Mercator (UTM) projection, Zone 15, using North American Datum of 1983 (NAD).

The VMP provides an array of data products (<http://biology.usgs.gov/npsveg/overview.html>). Spatial data products include aerial photographs, map classification, map classification description key, spatial database of vegetation communities, hard-copy maps of vegetation communities, metadata for spatial databases, and an accuracy assessment of the vegetation map. Vegetation information includes vegetation classification of the communities found at EFMO, dichotomous field key to the vegetation classes, formal descriptions and ground photos of the vegetation classes, and field data in database format. More VMP information and products of completed park mapping projects are on the Internet at <http://biology.usgs.gov/npsveg>.

Natural Resource Inventory and Monitoring Program

The NPS Natural Resource I&M Program is a long-term effort to acquire information needed to help maintain ecosystem integrity for all National Park units with significant natural resources. One I&M Program long-term goal is to produce baseline inventories of basic biological and geophysical natural resources. The VMP provides detailed vegetation maps based on aerial photographs and meets specified thematic accuracy standards (80%) set by the I&M Program. In producing vegetation maps, the VMP also provides a listing of plant species derived from its mapping projects, contributing yet another I&M Program baseline inventory product. More information on the I&M Program is on the Internet at <http://www.nature.nps.gov/im/>.

Vegetation Mapping Program Standards

The VMP uses nationally defined standards, some of which are maintained by the FGDC. These include the

- National Vegetation Classification Standard (Federal Geographic Data Committee [FGDC] 1997),
- Content Standard for Digital Geospatial Metadata (FGDC 1998a),
- Spatial Data Transfer Standard (FGDC 1998b),
- United States National Map Accuracy Standards (U.S. Geological Survey 1999), and
- Integrated Taxonomic Information System (U.S. Department of Agriculture, USDA).

Descriptions and links to websites for these standards can be accessed on the VMP website (<http://biology.usgs.gov/npsveg/standards.html>).

The National Vegetation Classification Standard

The FGDC adopted the National Vegetation Classification Standard in 1997. The purpose of the classification standard is to ensure consistent classification of vegetation resources across regions. The use of a standardized national vegetation classification system aids effective resource stewardship by ensuring compatibility and helps widespread use of the information throughout the NPS and other Federal and state agencies.

The National Vegetation Classification Standard is hierarchical with five physiognomic levels and two floristic levels (Table 1, Grossman et al. 1998). Key attributes of the classification standard are it is (1) based on existing vegetation, (2) applied to natural resources, and (3) a hierarchical system defined by physiognomy and floristics (Faber-Langendoen 2001). The classification is based on the United Nations Educational, Cultural, and Scientific Organization (UNESCO) world physiognomic classification of vegetation (United Nations Educational, Cultural, and Scientific Organization (UNESCO) 1973), which was modified to provide greater consistency at all hierarchical levels and include additional types, thus setting up the framework for the upper physiognomic levels (Grossman et al. 1998, Drake and Faber-Langendoen 1997). The lower floristic levels are devised from a national framework used by The Nature Conservancy (and now by NatureServe) and their network of state heritage programs for more than 20 years (Grossman et al. 1998). The physiognomic-floristic classification includes all upland terrestrial vegetation and wetland vegetation with rooted vascular plants.

Table 1. National Vegetation Classification System physiognomic-floristic hierarchy for terrestrial vegetation.

Level	Primary Basis For Classification	Example
Class	Growth form and structure of vegetation	Woodland
Subclass	Growth form characteristics (e.g., leaf phenology)	Deciduous woodland
Group	Leaf types, corresponding to climate	Cold-deciduous woodland
Subgroup	Relative human impact (natural/semi-natural or cultural)	Natural/semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Temporarily flooded cold-deciduous woodland
Alliance	Dominant/diagnostic species of uppermost or dominant stratum	*Populus deltoides* temporarily flooded woodland alliance
Association	Additional dominant/diagnostic species from any strata	*Populus deltoides* - (*Salix amygdaloides*) / *Salix exigua* woodland

The coarsest physiognomic level of the classification is "class" and categorizes vegetation on its most basic physiognomic structure (e.g., forest, woodland, shrubland). The finest physiognomic level is "formation" and categorizes vegetation by dominance of a given growth form in the uppermost stratum and characteristics of the environment (e.g., cold-deciduous alluvial forests).

The two floristic levels are alliance and association and are the two finest levels of the classification standard. These levels are based on species composition (Maybury 1999) and are developed from dominant or diagnostic species rather than physiognomic patterns of dominant species (Grossman et al. 1998). Faber-Langendoen (2003) explains dominant species as plant species of predominance in a community because of its size, abundance, or coverage. Characteristic (diagnostic) species, in contrast, are plant species almost always found in a particular community and used in the delimitation of that community. An alliance type has been described as a group of physiognomically uniform plant associations sharing dominant or diagnostic species, usually in the uppermost strata of the vegetation (see Mueller-Dombois and Ellenberg 1974 as cited in Drake and Faber-Langendoen 1997), e.g., QUERCUS ALBA - (QUERCUS RUBRA, CARYA SPP.) FOREST ALLIANCE. The association is the finest level in the classification and has been defined as "a plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (see Flahault and Schroter 1910 in Morovac 1993 as cited in Drake and Faber-Langendoen 1997), e.g., *Quercus alba* - *Quercus rubra* - *Carya ovata* Glaciated Forest. Most schools of floristic classification have used this concept. The classification standard is hereafter referred to as the National Vegetation Classification System (NVCS).

Content Standard for Digital Geospatial Metadata

Metadata are data about data and describes the content, quality, condition, and other characteristics of data. As a standard product, the VMP employs FGDC compliant metadata files for each spatial data set it produces. In 1998, the FGDC approved the Content Standard for Digital Geospatial Metadata: FGDC-STD-001-1998 (FGDC 1998a). This metadata standard uses a common set of terminology and definitions to document digital geospatial data. For spatial data sets involving biological components, the VMP uses the FGDC endorsed Biological Data Profile (a profile is a set of information specific to a discipline, in this instance the biological sciences discipline), a biological metadata standard developed by the National Biological Information Infrastructure (NBII). This is known as the Biological Data Profile of the Content Standard for Digital Geospatial Metadata: FGDC-STD-001.1-1999 (FGDC 1999).

Effigy Mounds National Monument

History and Location

Effigy Mound National Monument was established in 1949 by presidential proclamation and inaugurated with a 405-ha (1000-acre) gift from the state of Iowa (York O'Bright 1989). Additional tracts of land have since been added to EFMO, including the most recent in December 2000 when the Iowa Natural Heritage Foundation transferred 423 ha (1045 acres) to the NPS (HRA Gray and Pape 2003), expanding the EFMO lands by 70%. Today, EFMO totals 1,022 ha (2,526 acres; accessed 12/17/2003 <http://www.nps.gov/efmo/pphtml/facts.html>).

Located in northeastern Iowa in Allamakee and Clayton counties (Figure 1), EFMO is adjacent to the Mississippi River in a topographically unique area known as the Paleozoic Plateau region. The EFMO headquarters is 3 miles north of Marquette, Iowa. The main section of EFMO, the Yellow River Unit, envelops the Yellow River near its confluence with the Mississippi River (Figures 2–3). The Yellow River subdivides this unit into the North and South Units closest to the Mississippi River. The newly acquired Heritage Unit, also known as the Kistler-Ferguson Tract, is adjacent to the North and South Units toward the west. Collectively, these three units are known as the Yellow River Unit. The addition of the Heritage Unit connects EFMO lands to a section of Iowa's Yellow River State Forest (Figure 4), making over 1,619 ha (4,000 acres) of contiguous public and protected lands (accessed 12/17/2003 <http://www.inhf.org/dedicationpr.htm>). The Sny Magill Unit is approximately 16 km (10 miles) south of headquarters within the Mississippi River floodplain (Figure 3).

Figure 1. Location of Effigy Mounds National Monument in Iowa.

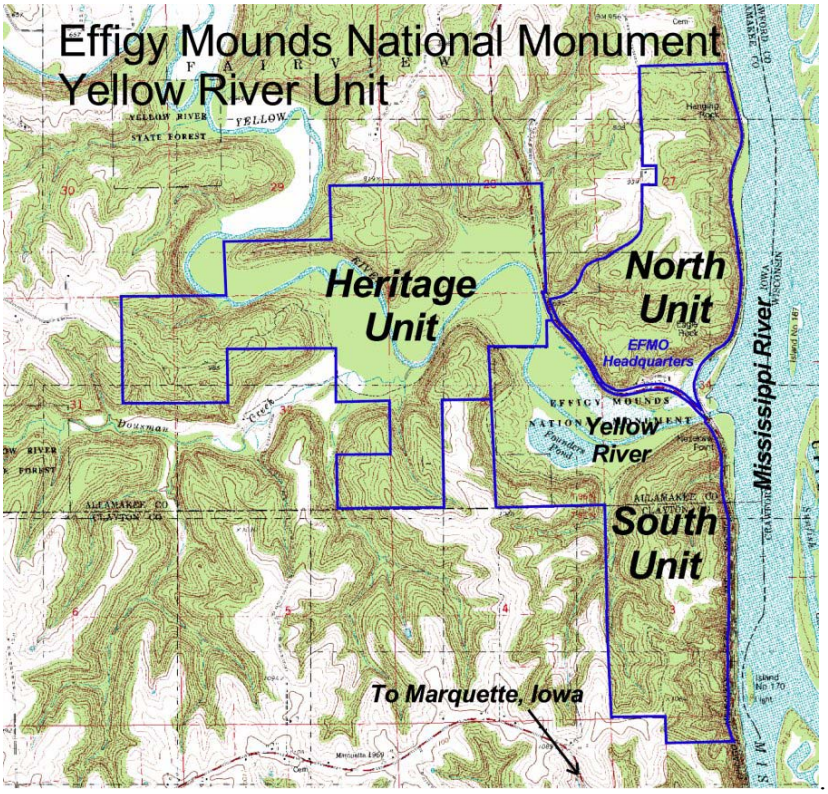


Figure 2. Location of the Yellow River Unit.

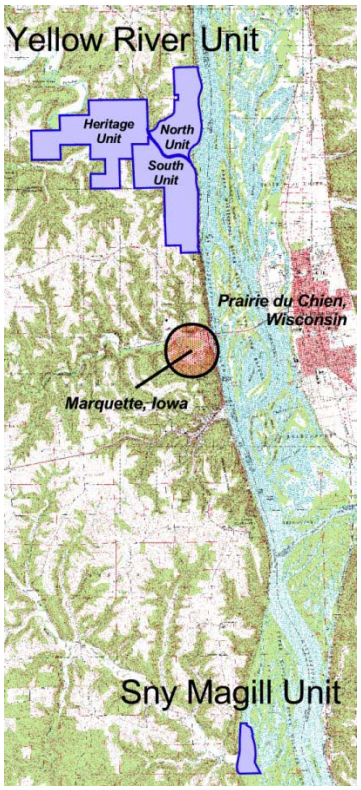


Figure 3. Locations of the Yellow River and Sny Magill Units.

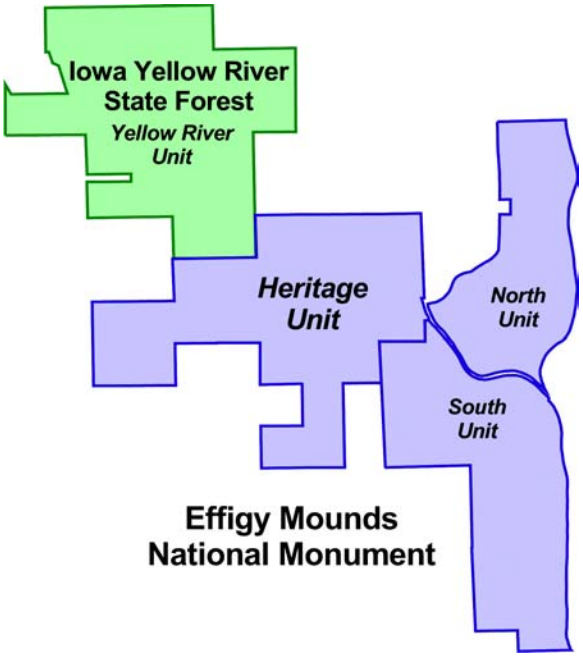


Figure 4. The portion of Iowa's Yellow River State Forest bordering Effigy Mounds National Monument.

The cultural, wildlife, and forest resources of EFMO, along with scenic bluff vistas (Figure 5) bring many tourists to the area, especially during the fall when the leaves are changing colors. Numerous groomed hiking trails provide excellent access to the EFMO cultural and natural resources.

Figure 5. Scenic view of Hanging Rock, Effigy Mounds National Monument.

Cultural Resources

Since 1949, EFMO has been preserving a remnant of cultural resources of the area, ceremonial burial mounds. Most of the mounds are recognized as built by the Eastern Woodland Indians starting around 500 BC until the early European contact period (accessed 12/17/2003 <http://www.nps.gov/efmo>) with 195 known mounds at EFMO (HRA Gray and Pape 2003). Most of the mounds are conical, linear, or compound (containing more than one mound; Figure 6), but 31 are in the shape (effigy) of animals, most commonly falcons and bears (Figure 7). These effigy mounds are only in northeast Iowa, southeast Minnesota, and southern Wisconsin. In recent years, EFMO has begun to actively manage for these cultural resources, which involves managing the natural resources of the park, including vegetation.

Figure 6. A series of Indian burial mounds.

Figure 7. An effigy mound in the shape of a bear.

Natural Resources

The bluff area adjacent to the Mississippi River is the steepest and most rugged portion of the park with narrow ridge tops, interior ravines, and valleys. Sandstone and limestone are the major forms of bedrock at EFMO, all within a physiographic region known as the Paleozoic Plateau (U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS] 1998). Westward, the topography becomes more undulate and includes the Yellow River floodplain.

Bailey (1995) describes the region as the Eastern Broadleaf Forest (Continental) Province, one dominated by broadleaf deciduous forest favoring the drought-resistant oak-hickory association with savannah-like communities transitioning into prairies toward its northern reaches. In the northern reaches of this province, however, where EFMO lies, maple and basswood become a prominent part of the deciduous forest. Faber-Langendoen (2001) indicates the Paleozoic Plateau is favorable to forested conditions.

At EFMO, upland forests and woodlands coexist with communities typical of central and western Iowa, such as Central Tallgrass communities, creating a unique mix of communities on the upland bluffs. Upland forests are dominated by red oak, sugar maple, shagbark hickory, white ash, and American basswood (Figure 8). White and chinquapin oak trees favor the dryer sites along the ridges and bluff tops (Figure 9). Eastern red-cedar also speckles the bluff outcrops and overhangs, its presence due, in part, to fire suppression and grazing pressure (Figure 10). Small prairie remnants, goat prairies, grow along south-facing bluffs where soils are thinnest. Blewitt (1986), drawing upon a series of historical accounts and documents and climate and geology data, suggests the area was widespread with native tall grass prairie and savanna during presettlement days. The earliest permanent settlement in the area was 1833 (USDA NRCS 1998). This area and other early settlement areas have been primarily converted to agriculture. Of recent years, EFMO has been returning some of their old fields to tall grass prairie through a native grassland restoration effort (Figure 11). These old fields historically may have been oak savanna.

Figure 8. Inside an oak - hickory forest.

Figure 9. White oak trees on a ridge top setting.

Figure 10. Red-cedar trees nestled above a bluff glade.

Figure 11. A restored tallgrass prairie unit.

Wetlands are primarily restricted to river floodplains and broad ravines. Wetlands outside of the bottomlands are typically small artificial ponds used for livestock. Along the Mississippi and Yellow Rivers, most plant communities are typical of large river systems, however impoundments and dams along the Mississippi River create conditions for communities more typical of slower flowing waters. The floodplain wetlands, including the lower portion of the Yellow River, are influenced by the navigation water management of the Mississippi River (controlled by the U.S. Army Corp of Engineers with locks and dams). Wetland forests of these large river systems consist primarily of silver maple, cottonwood, green ash, and elm (Figure 12). Swamp white oak and bur oak are more occasional. Willow and buttonbush make up the floodplain shrubs. Herbaceous marsh plants and aquatic macrophytes flourish in the floodplain forest openings and river oxbows, including reed canary grass on dryer sites, and river bulrush, burreed, rice cutgrass, arrowhead, white water lily, American lotus, and submersed aquatic plants in wetter sites.

Figure 12. Hardwood floodplain forest near the confluence of the Yellow and Mississippi Rivers.

Historically, much of the forest, both upland and wetland, has been harvested or thinned through mechanical means, altering the dominance or presence of tree species (Figure 13). Some reforestation efforts have taken place during the last century. In the 1940s, the Iowa Yellow River State Forest planted most of their open land to trees, resulting in the pine plantations present in the area (accessed 1/16/2004 <http://www.iowadnr.com/forestry/yellowriver.html>. The area surrounding EFMO is primarily cropland and permanent pastureland. Although half the area is forested (Narumalani et al. 2002), these lands are also commonly used for livestock grazing and rangeland. Dairy, cattle, and hog farms are the primary farming practices in the area (USDA NRCS 1998).

Figure 13. Hardwood forest with selective oak tree harvesting.

Previous Vegetation Studies

Over the years, vegetation surveys have been conducted at EFMO. More recent are Howell et al. (1983) with a comprehensive survey of upland forest vegetation and Blewett (1986) with a complimenting survey of grasslands and rare plants. Both the Howell and Blewett studies provided a more comprehensive understanding of the resources within NPS lands and contributed to EFMO park management (Blewett 1986). Howell recommended additional surveys of plant communities on a regular basis, particularly for long-term population studies of the rare woodland species. Intensive vegetation sampling was conducted in savanna, prairie restoration, and goat prairie sites at EFMO for the NPS Prairie Cluster Prototype Long-Term Ecological Monitoring (LTEM) Program (of the NPS I&M Program). Narumalani et al. (2002) produced a general land cover map of EFMO and a 5-km radius outside the park boundary using IKONIS pan-sharpened satellite imagery acquired October 2000 (same date as this project's aerial photography). The map classification Narumalani used is actually a modified and condensed version of the preliminary map classification for this project, although the classification for this project has changed considerably since the Narumalani study. (The analysis of vegetation sampling data resulted in numerous revisions to the preliminary map classification.) Narumalani plans to map vegetation using 1940 and 1960 black and white photos of the coincident area to evaluate landscape changes over a 60-year period. The initial results from mapping the 2000-dated IKONOS imagery showed 50% of the area as deciduous forest and nearly 35% of the area as cropland and pasture, showing anthropogenic activities in the area.

This project provides, for the first time in EFMO's history, an extensive ground survey of plant communities complimented with a detailed map representing those plant communities. Since its establishment in 1949, preserving and understanding EFMO's cultural resources have been forefront. The archeological significance of the site has overshadowed the biotic features of the monument area (Blewett 1986). Recently, however, EFMO management has been progressing toward an active management approach toward cultural resources that embraces biotic features, including vegetation. It is our hope this study will provide cultural and natural resource managers and researchers spatial and nonspatial tools and information to better aid them in attaining their goals.

Project Overview

General Process

The three main components of the EFMO Vegetation Mapping Project are vegetation classification, vegetation mapping, and map accuracy assessment. Our objectives were to identify and map existing vegetation communities of EFMO and environs. Before formally beginning the project, we acquired two sets of aerial photographs of the study area (collected summer and fall of 2000), giving us aerial photographs in hand for the following year's fieldwork activities. We officially began the project in spring 2001 with a scoping meeting of primary partners to discuss and plan the project. We brought to this meeting a preliminary vegetation classification of possible plant communities of EFMO.

During summer 2001, we collected vegetation samples for later analyses and documentation. Before beginning our sampling fieldwork, mappers and ecologists visited several locations at EFMO to validate plant communities of the preliminary classification and to determine a strategy to sample vegetation communities. We entered the vegetation data into the PLOTS Database System (TNC 1997) and analyzed the data the following winter. The analyses provided us detailed ecological information to affirm the plant communities at EFMO and document them with local descriptors. We collected additional vegetation samples during summer 2002 (during the accuracy assessment sampling period, see below) to better characterize some wetland vegetation types. We finished full vegetation descriptions of EFMO the fall of 2003.

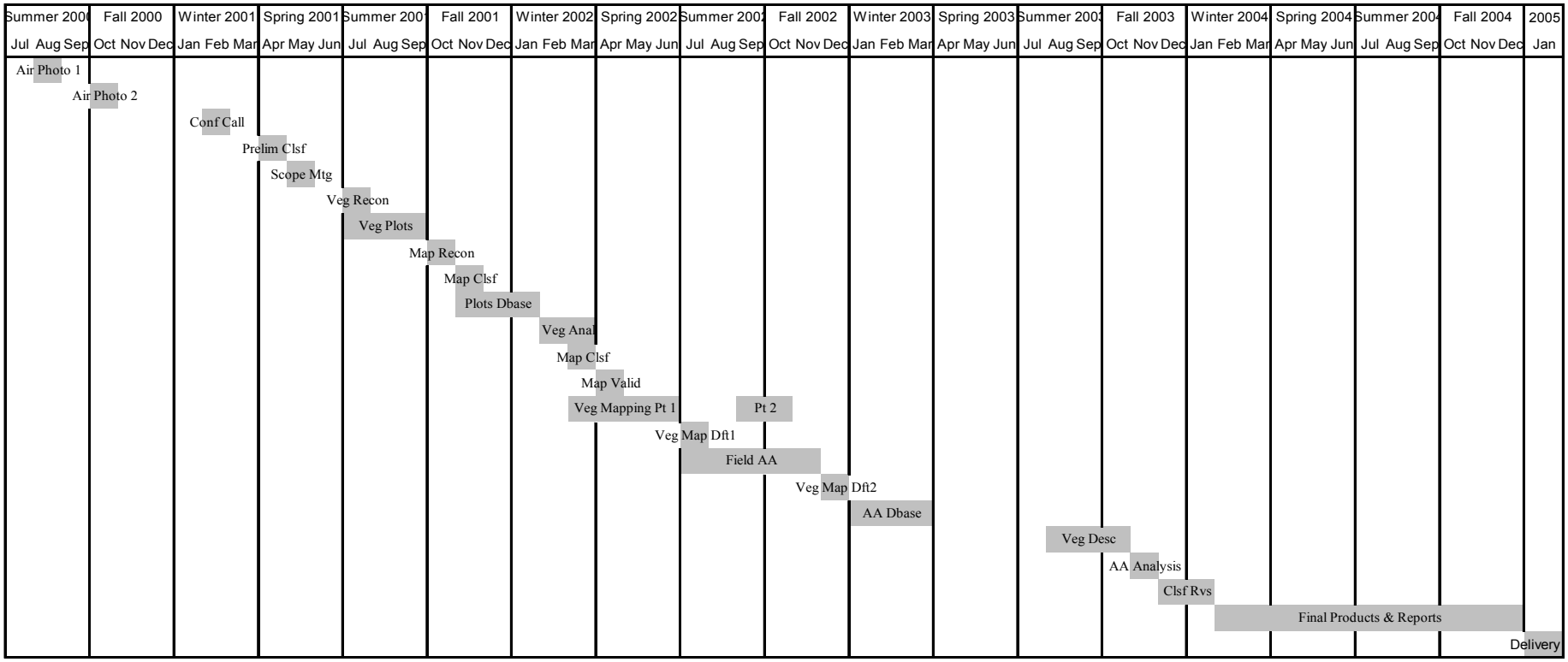
An understanding of plant communities is essential for mapping them. With a compressed timeline for finishing the project, having the vegetation analyses complete and plant community descriptions in hand before mapping was not possible. However, as vegetation concepts became known, either from field or lab, we applied them to our photointerpretation mapping. Before mapping, we performed additional field reconnaissance in fall 2001 to learn how the vegetation appears on the aerial photographs. We conducted our reconnaissance about the same time the photos were collected the previous year, giving us a similar perspective of foliar changes at the time of photography. We refined the map classification immediately following our field investigations, and developed more extensive mapping protocols. We began mapping (photointerpretation and digital map automation) during the spring of 2002 once we completed the preliminary vegetation analysis. Although community descriptions were not yet written, the vegetation analyses enabled us to better understand the plant communities and to revise our map classification and mapping conventions.

We completed a draft digital version of the map in time for the 2002 field season, in which we collected field data for an accuracy assessment to the map. We evaluated the map for accuracy using the field data, tabulating the results into a contingency matrix. Per VMP protocol, only map classes representing plant communities are included in the accuracy assessment.

We made final revisions to the vegetation classification and map coverage before compiling all VMP final products for delivery. Table 2 shows the project's general timeline of events and activities.

In addition to map coverages of vegetation and land use, we developed spatial coverages showing locations of our map reconnaissance sites, vegetation sampling plots, and accuracy assessment sites. All geospatial products are in the UTM projection, Zone 15, using NAD83.

Table 2. Timeline of activities for the Effigy Mounds National Monument vegetation mapping project.



Primary Partners and Individuals

The Effigy Mounds National Monument Vegetation Mapping Project is a cooperative effort among several agencies and organizations. The primary partners and individuals in their respective roles are

USGS Center for Biological Informatics (CBI)
Tom Owens - budgeting and project oversight (through December 2001)
Karl Brown and - budgeting and project oversight (beginning January 2002)
Susan Stitt - project oversight (beginning January 2002 through spring 2004)

USGS Upper Midwest Environmental Sciences Center (UMESC)
Kevin Hop - project management lead, map classification, photointerpretation, report writing, metadata, and final product compilation
Sara Lubinski - vegetation sampling lead and analyses, vegetation classification, map classification, quality control of data, accuracy assessment, and report writing
Brian Pruka - vegetation sampling, plant identification, and map classification
Mara May - vegetation sampling, data quality control, and accuracy assessment set-up
Christine Calogero Lovelace - vegetation sampling, PLOTS database entry, digital spatial products
Janis Boyd - map overlay ortho rectification and orthophoto mosaic

NPS Natural Resource Inventory and Monitoring (I&M) Program
Mike Story - budgeting and project oversight
Chris Lea - project oversight (beginning summer 2003)

NPS Effigy Mounds National Monument (EFMO)
Phyllis Ewing - advisory re park information and support
Rodney Rovang - advisory re park management and information, primary park contact, and park access

NPS Midwest Regional Office
Phyllis Adams - advisory re I&M Program
Peter Budde - advisory re supporting spatial data sets
Kathie Hanson - fire fuels variables and initial project boundary

NatureServe
Jim Drake - project management re NatureServe responsibilities
Shannon Menard - vegetation classification and analysis lead

Responsibilities and Products

Various tasks and products were assigned to the primary partners. Many assignments came logically considering the partner's specialty of service and others came as a result of the scoping meeting. Some assignments are shared in a cooperative effort. The following lists the tasks and products for which each partner was responsible.

USGS UMESC

- Facilitate project activities
- Sample representative stands of plant communities
- Develop a PLOTS-generated database of vegetation field sample data and accuracy assessment field site data
- Collaborate in the vegetation sampling analysis
- Develop a vegetation key to plant communities
- Write local descriptions of plant communities

- Perform field reconnaissance to learn photo signatures and local ecology, and to verify vegetation and land use appearances on aerial photographs
- Develop map classes that link to the NVCS and other classification systems
- Interpret and delineate vegetation and land use types using aerial photographs
- Digitally automate interpreted data to produce a digital spatial vegetation coverage (vegetation map) for use in geographic information systems (GIS)
- Provide a photointerpretation mapping convention report and key
- Design, collect, an analyze accuracy assessment validation sites
- Produce digital spatial coverages of all field collection sites and report results
- Provide final report describing all aspects of the project
- Document FGDC compliant metadata for all spatial data (and NBII compliant metadata for all vegetation spatial data)
- Produce hard-copy reports and maps
- Provide a CD-ROM containing reports, metadata, keys, classification lists, fieldwork data, spatial data, map composition, graphics, aerial photographs, and ground photos of vegetation work

NatureServe

- Provide UMESC guidance in vegetation sampling and design
- Provide vegetation sampling analysis, classification development, and descriptions
- Provide global descriptions to plant communities, and oversee UMESC with local descriptions
- Provide documentation on vegetation analyses methods
- Assist UMESC in PLOTS database management

NPS EFMO

- Host the scoping meeting and provide infield tour of EFMO
- Provide UMESC and NatureServe with guidance and general access to EFMO lands
- Contact private and government neighbors within project extent, and acquire access permission as needed
- Provide collection permits
- Review the preliminary classification

NPS Midwest Regional Office

- Develop fire fuels variables
- Provide UMESC preliminary boundary coverage
- Provide UMESC base GIS layers for mapping

Aerial Photography

An essential step for each VMP project is the acquisition of aerial photographs. Aerial photographs provide the baseline imagery data in mapping plant communities and other landscapes. Vertical photographs (photographs taken with the aerial camera pointed straight down at the ground) collected with proper overlapping in each flight line permit an interpreter to study the photographs three-dimensionally with a stereoscope (Avery 1978). This type of photography is essential in mapping ecological plant communities.

A variety of aerial photograph film emulsions are available to choose from and Avery (1978) concludes no single film emulsion serves all purposes. We chose color infrared (CIR) film, also called modified-color or false-color film (Eastman Kodak Company 1987), for this project because of its ability to penetrate atmospheric haze (Eastman Kodak Company 1985) and its simplicity in differentiating between plant species (Crisco 1988) as false-color films emphasize differences between objects that are visually quite similar. This type of film is particularly useful when plant species and their foliage begin to senesce

at different rates in the fall. For example, modified-color renditions for healthy-deciduous, green foliage produce red colors on CIR photographs, diseased or deficient foliage produce greens or blues, and heavily stressed foliage produce yellows (Eastman Kodak Company 1987). Hershey and Befort (1995) explain vegetation reflects more infrared than visible light, and thus helps subtle differences in physical characteristics of species to show up as large differences on CIR film. In addition, CIR imagery presents a "false color" picture that combines infrared reflectance with green and red visible bands. The differences in reflectance create differences in color, allowing the photointerpreter to see the distinguishing features of different plant species and vegetation communities. Reflectance is influenced by structure of the canopy, the orientation of the plants and their leaves, and the thickness and pigment contents of leaves. We chose CIR over natural color or black and white emulsions because it is best suited for mapping vegetation and is least influenced by atmospheric haze.

Acquisition

To determine our photo extent, we determined the needs and preferences of EFMO. Typical with most VMP projects, the project area extends beyond park unit boundaries. The question before us was how far beyond. With EFMO's North, South, and Heritage Units in proximity to some Iowa state forest lands and EFMO's interest in the Wild and Urban Lands Interface program, we defined a photo mission covering the extent as seen in Figure 14, knowing the final mapping extent would be determined later during the scoping meeting the following year.

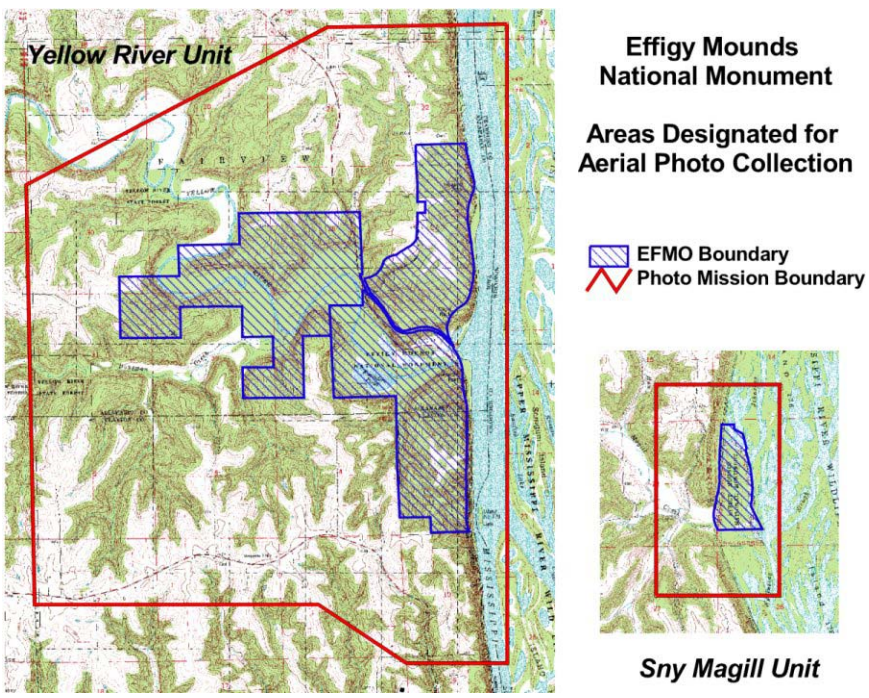


Figure 14. Aerial photo mission plan for the Effigy Mounds National Monument vegetation mapping project.

We collected two sets of aerial photographs for this mapping project. The first set was collected August 25, 2000, complimentary of the UMESC and collected as a side mission during another photo mission over the Mississippi River. The second set, funded by the VMP, was collected October 9, 2000 to capture fall leaf phenology conditions (Figure 15). Each photograph set is CIR, however, the August set is 1:15,000-scale, and the October set is 1:8,000-scale. For each set, we acquired the original 9 x 9-inch

positive transparencies. HAS Images Inc. (Dayton, Ohio) processed the film, and produced the contact prints for each photograph set. We acquired one set of 9 x 9-inch contact prints for the August set, and two sets of contact prints for the October set.

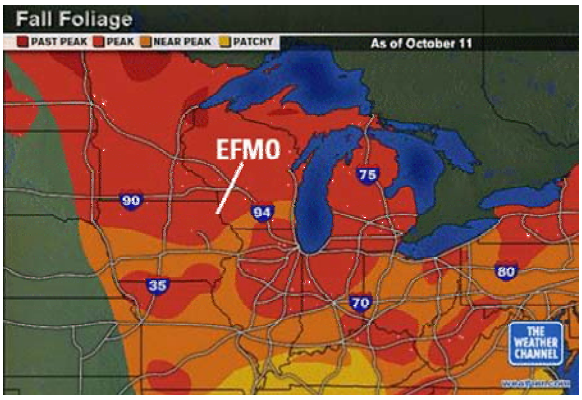


Figure 15. Location of peak fall foliage near the date of aerial photography.

Specifications

The UMESC collected both aerial photograph sets in a cooperative effort with the U.S. Fish and Wildlife Service (USFWS) Region 3. Mounted in a USFWS Partenavia twin-engine aircraft, we collected aerial photographs using a Ziess Jena LMK 2000 camera (Figure 16) loaded with KODAK AEROCHRME II Infrared Film 2443. To assure stereo viewing and full aerial coverage, we planned both missions to collect photos with a 60% forward-lap and a 30% side-lap.

Figure 16. Ziess Jena LMK 2000 camera mount inside USFWS Partenavia twin-engine aircraft.

We collected the 1:15,000-scale photographs at an elevation above ground level (AGL) of 7,500 ft. The photo mission required three flight lines to cover the Yellow River Unit, and one more flight line to cover the Sny Magill Unit. In all, 28 aerial photos were collected on August 25, 2000 (24 photos Yellow River Unit, 4 photos Sny Magill Unit, Figures 17).

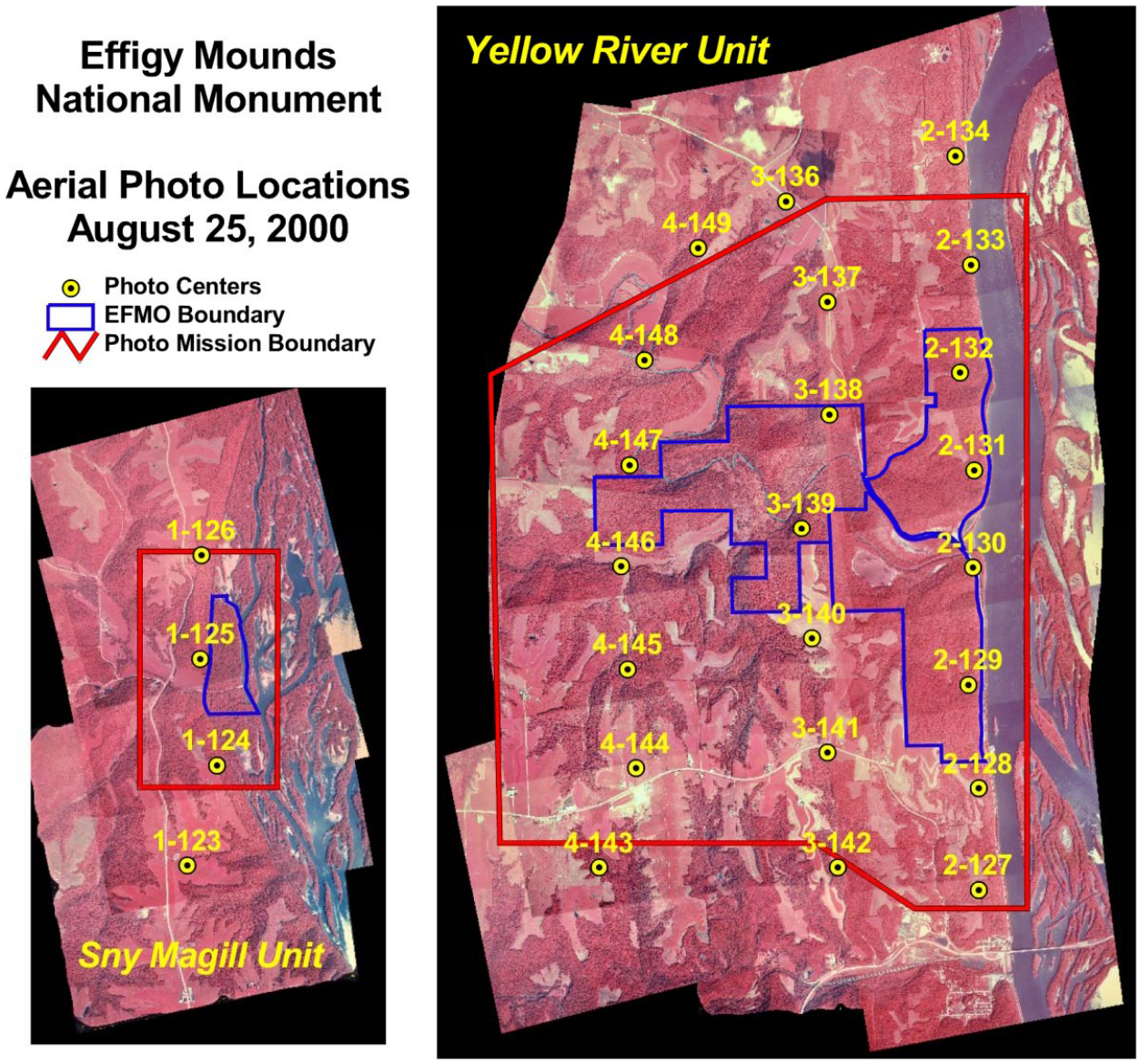


Figure 17. August 2000 aerial photo locations.

We collected the 1:8,000-scale photographs at an elevation AGL of 4,000 ft. The photo mission required five flight lines to cover the Yellow River Unit, and another two flight lines to cover the Sny Magill Unit. In all, 69 aerial photos were collected on October 9, 2000 (57 photos Yellow River Unit, 12 photos Sny Magill Unit Figures 18).

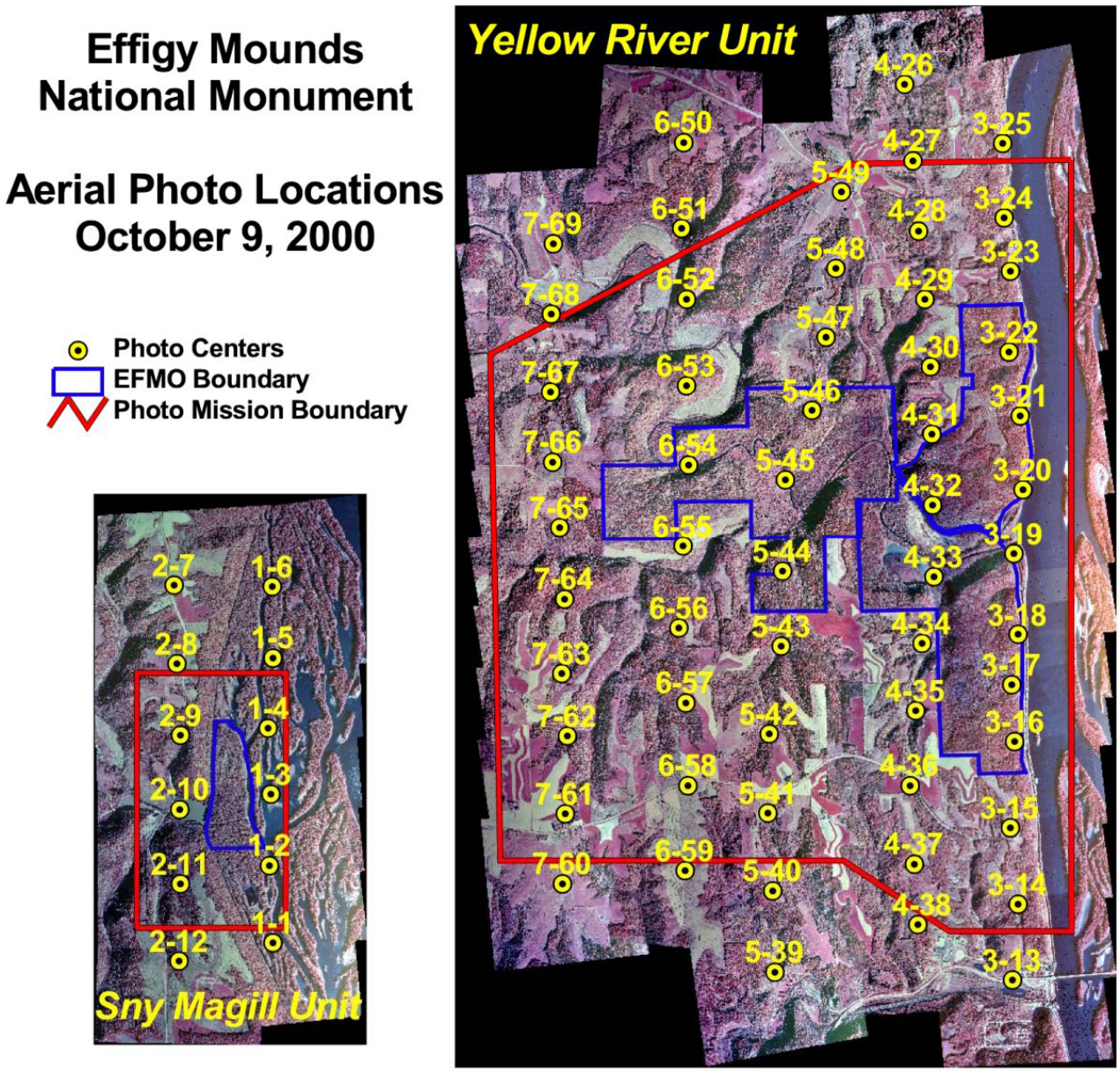


Figure 18. October 2000 aerial photo locations.

We have produced spatial database sets for use in GIS of each of these aerial photo sets showing the locations of each aerial photograph.

Assessment and Use

Our intention was to use the October photographs as the baseline product for mapping, and use features of the August photographs to provide additional information not captured with the October set. The August 2000 photograph set captured peak vegetation biomass production as we expected (Figure 19). Even with CIR, however, the color and tone distinctions between vegetation types can be quite narrow (e.g., between various deciduous forest types). Although photographs collected during peak biomass can benefit the mapping of wetland vegetation, the majority of the map extent is upland forest habitat. Careful study of vegetation textures can reveal subtle differences and clues to distinguish between similar appearing

vegetation types. More pronounced distinctions, however, would make mapping more efficient and definite. Using the August 2000 photographs for mapping plant communities, we believe, would be challenging. Yet, we were optimistic the August photographs would be a help in interpreting the October photographs.

Figure 19. Example of an August 2000 aerial photograph collected for the vegetation mapping project.

The October 2000 photo mission captured close to peak fall tree foliage (Figure 20). Colors and tones for trees show a good range of reds, pale reds and pinks, off-whites, and grays (Figure 21). Forest type color and tone distinctions are more recognizable than with the August photographs. The 1:8,000-scale photographs better captured many vegetation characteristics compared to the 1:15,000-scale photographs, particularly with tree crowns. Most wetland emergent vegetation is easily distinguishable from each other, with the exception of early-senescing plants, such as aquatic macrophytes and arrowhead. The largest drawback with the October 2000 photographs is the dark shadows cast along steep northerly aspects of valleys and bluffs. The shadows obscure the underlying vegetation on CIR. (The less steep hillsides do not have this problem). With low sun angle during fall months in this latitude, we had to expect this. Collecting true color photographs may have improved viewing through these shadow areas. However, narrower color distinctions and possible implications from haze deterred us from using true color photographs.

Figure 20. An oblique aerial photo collected at date of photography showing peak fall tree foliage.

Figure 21. Example of an October 2000 aerial photograph collected for the vegetation mapping project.

We evaluated leaf phenology conditions at EFMO the day after the October photo mission. Knowing we would not have the aerial photographs in hand for a few weeks, we wanted to know the leaf conditions immediately after the date of photography. We collected some general notes and digital ground photos of various tree species and their leaf phenology stage. We discovered different stages of leaf senescence and leaf-off even within a particular species (Figure 22) and assumed this was likely due to differing positions in the landscape (e.g., protected or exposed) and hydrology (e.g., dry or mesic).

White ash with green foliage, North Unit EFMO, October 10, 2000 White ash with senesced foliage, North Unit EFMO, October 10, 2000

Figure 22. Variations of white ash foliage as seen one day after the October photo mission.

All things considered, we judged the October 2000 photographs suitable for mapping vegetation and land use features for this mapping project. The August 2000 photographs would help us with problematic areas present on the October photos, especially, areas with intense shadows and senesced vegetation of deep-water habitats.

Scoping Meeting

We officially launched the mapping project with a scoping meeting held at EFMO headquarters May 1 and 2, 2001. Various cooperators joined together to discuss the project's objectives and methods, receive assignments, and view first hand EFMO's landscape. Individuals from NPS, including EFMO, Midwest Regional Office (I&M Program and GIS), and Prairie Cluster LTEM Program, USGS CBI and UMESC offices, and NatureServe Minneapolis Office met to

- Inform EFMO staff and interested neighbors of the USGS-NPS VMP,
- Learn about EFMO's management and science issues and concerns,
- Learn about existing data,
- Develop a preliminary schedule with assigned tasks,
- Get commitment from EFMO,
- Define possible cooperation with neighbors and partners,
- Define project boundary.

At EFMO's scoping meeting, we learned of EFMO's management plan and issues regarding vegetation. Of particular importance to EFMO resource management is to restore the landscape to the mound-building era, with forested areas more open than they are today. Many oak-hickory type forests are in rapid succession toward maple-basswood, changing the canopy cover and understory plants, and a map showing these transitions would be helpful. Old fields are filled with exotic or weedy plant species with little native seed source. Thus, EFMO has moved into a prairie restoration effort of reseeding with native plants and managing with prescribed burns. NPS is monitoring very closely the edge effect of these prairies to the bordering forests. We also learned EFMO is quite interested in small (<0.5 ha, 1.25 acres) prairie forest openings (e.g., goat prairies). Since many of these are less than the VMP standard minimum mapping unit (MMU), we considered mapping goat prairies and other similar types below standard MMU.

Project Boundary and Map Extent

The mapping project includes all EFMO lands, including the entire Yellow River Unit (North Unit, South Unit, and newly acquired Heritage Unit), and the Sny Magill Unit further to the south (Figure 23). The project area also includes lands surrounding EFMO, a minimum of a half-mile radius and usually well beyond. Input from NPS Midwest Regional Office fuels specialist indicated satisfaction with a half-mile radius around all units (email correspondence with Kathy Hansen, May 23, 2001). Nonetheless, we did include areas beyond the half-mile radius. With respect to EFMO's interest in the National Wildland/Urban Interface Fire Program (a program with focus on fire management of those areas where "wildland" and human development intermingle), we enlarged the map extent north to the Luster Heights complex and south to Marquette, Iowa. In addition, with increased collaboration between EFMO and the Iowa Yellow River State Forest, we extended our map boundary to include some of Iowa's Yellow River State Forest lands, including the entire Yellow River Unit, most of the Lost 40 Unit, and portions of the Mudhen and Luster Heights Units (see Figure 23). The extent around the Sny Magill Unit is the minimum half-mile radius, which extent includes some Iowa Department of Natural Resources (DNR) lands. More Iowa DNR lands are included within the project extent near the Luster Heights state forest unit.

Our map extent is 4,972 ha (12,286 acres), including all EFMO lands and extended environs. EFMO comprises 1,022 ha (2,526 acres; 21%) of the total map area, and those portions of Iowa's Yellow River State Forest lands we mapped are approximately 563 ha (1,390 acres; 11%) of the total map area. We produced a spatial database set for use in GIS of the project boundary extent.

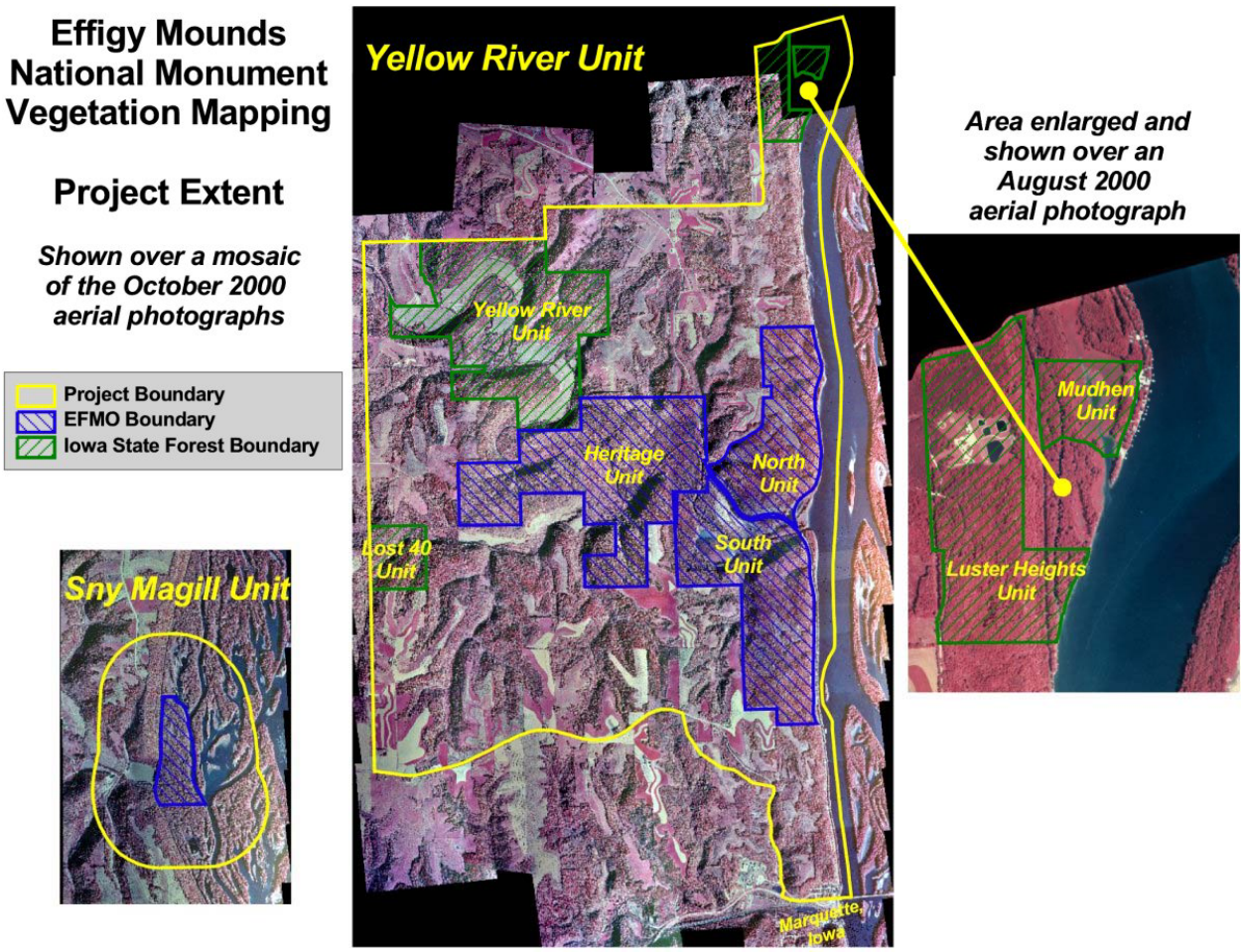


Figure 23. Project map extent with Effigy Mounds National Monument and Iowa State Forest boundaries.

Minimum Mapping Units

Park specific needs, small map area (4,972 ha, 12,286 acres) and large-scale photography (1:8,000-scale), moved us to map below the standard MMU for this project. We used an MMU of 0.25 ha (0.6 acres) for all map classes with the exception of a few map classes (e.g., goat prairies) where we mapped to 0.1 ha (0.25 acres). We applied a secondary MMU of 0.5 ha (1.25 acres) for physiognomic feature changes within a particular map class. We used MMU templates to help us determine minimum polygon size on the photographs during mapping. Because of angle distortions inherent to nonrectified aerial photos, and slight scale changes from high ridges to valley bottoms, we applied our MMU mapping liberally.

Classification Organization

With this project, we have described and mapped plant communities (associations) of the NVCS. For organization and display purposes, we are using Ecological System (ES) units, a classification structure developed by NatureServe (NatureServe 2003b, Comer et al. 2003). NatureServe defines a terrestrial ecological system as a group of plant community types that tend to coexist within landscapes with similar ecological processes, substrates, or environmental gradients. NatureServe's intentions with ES units are for providing mesoscale classification units for applications to resource management and conservation. NatureServe emphasizes the natural portions of the landscape for upland and wetland ES units. Units defined for human-dominated areas do not exist in the ES classification at this time. Thus, for those

vegetation scenarios of cultural disturbance allowing us to map only to the NVCS Formation level, we developed four nonstandard categories to group the map classes representing those scenarios (Upland Shrubland and Herbaceous Vegetation, Wetland Herbaceous Vegetation, Forest Plantation, and Pasture and Cropland). The first two categories present NVCS natural/semi-natural Formation level vegetation types. The latter two present NVCS planted/cultivated Formation level vegetation types. To categorize non-vegetated features, we derived two more categories to organize open water and land use units (Open Water and Land Use). We organized the natural/semi-natural plant communities (associations) in the following five ES units:

- North-Central Interior Maple-Basswood Forest,
- North-Central Interior Dry-Mesic Oak Forest and Woodland,
- Paleozoic Plateau Bluff and Talus,
- Central Tallgrass Prairie,
- North-Central Interior Floodplain.

We have provided brief descriptions of each of these systems in Appendix A: Ecological System Units of Effigy Mounds National Monument. Refer to the NatureServe documentation (NatureServe 2003b, Comer et al. 2003) for a full description.

Vegetation Classification

Methods

Preliminary Classification List

The Association for Biodiversity Information (ABI), now NatureServe, provided a preliminary classification of potential plant communities (associations) for the project (Association for Biodiversity Information [ABI] 2001a), prepared for the scoping meeting May 2000. The preliminary classification is a subset of the International Classification of Ecological Communities (ABI 2001b) and covers plant associations and alliances attributed to EFMO. This document was a guide to the types and compositions of communities we expected to find during the mapping project and was used in the field during reconnaissance trips to identify plant communities encountered throughout the project area.

Field Sampling

Before collecting the plot data, we determined sampling standards for most existing data were not suitable as classification standards. Also, plot data collected by the NPS Prairie Cluster Prototype LTEM Program (unpublished data) were not useful for analysis of data describing goat prairies at EFMO, which were too small and varied to accommodate plots for this project. Goat prairie data were not collected.

Plots were to be within the park boundaries unless we discovered new vegetation types accessible for sampling outside the park (e.g., on public lands). Classification plot data were gathered for the EFMO mapping project so vegetation types could be described with enough detail for placement in the NVCS, which would then be used as the basic structure for the map classes. Methods were derived from those in Section 5 of the Field Methods for Vegetation Mapping manual (TNC and ESRI 1994b).

We chose to have the UMESC mapping team perform the field data collection. We had a qualified staff (e.g., a botanist and an ecologiest) to do the work. With an in-house team we could provide timely support for development of the map classes and better control over the data management and timelines required to complete the project.

The sampling design strategy was to collect at least three plots for every vegetation type within EFMO (including adjacent public lands) using aerial photographs, existing data, and field reconnaissance to locate potential sample areas for each type. As the areas were visited, we added plots for highly variable types and reduced the number for types of lower variability.

Determining ideal plot locations to best describe the forest communities, especially within the upland forests, was difficult because many stands have varying levels of disturbance (mostly from grazing and logging). Disturbance features alter the appearance of stands from that of a “typical” community, influencing composition and abundance of species and making it difficult to determine where some stands fit within the NVCS. The NVCS does not describe all the potential effects of different combinations of disturbances in the regional community descriptions because of the extremely variable affects such disturbances may have on the local examples of that community. For example, many forested stands at EFMO were logged, grazed, or both leading to differences in the frequency and constancy of the understory and overstory species. These differences are not consistent enough across a region to all be included within a national classification like the NVCS, but can be very important to a local area. Thus, our ability to understand the relation between disturbed forests at EFMO and the national classification was challenging, and many of the differences caused by various disturbances are expressed in the descriptions of the local phases of individual map classes. Also, extreme topography relative to the size and extent of the landforms resulted in many forest stands being transitional in composition, often containing floristic elements from two or three different communities in varying combinations. Through

the sampling and subsequent data analyses, we learned there are fewer communities of upland forests than appearances suggested.

Once representative stands were located, plots were placed so the typical features of each stand adequately represented only one vegetation type and were at least 15–20 m (50–65 ft) away from the boundary of another vegetation type. Table 3 shows plot sizes we used. We set up plots in square or rectangular shapes, although we made adjustments in size and shape if necessary to fit plant communities within small areas or irregularly shaped stands following narrow ravines or ridge tops (e.g., Chinquapin Oak Bluff Woodland plant community).

Table 3. Plot sizes used for vegetation community data.

Class	Area (m^2)	Dimensions (m)
Forest and Woodland	400	20x20 or 10x30
Shrubland	50-100	10x5 or 10x10
Herbaceous	50-100	10x5 or 10x10

Within each plot, boundaries were marked and the general physiognomy recorded. The vegetation was visually divided into layers (strata) and the average height, percent cover, and dominant species of each stratum was recorded using the cover scale in Table 4. Within each stratum, all species were identified, and the relative abundance of each was described by a visual percent cover estimate. In forest and woodland stands, the diameter at breast height (DBH) of all trees more than 10 cm (4 in) diameter were measured to describe stand structure and species. A provisional community name was assigned to each plot (e.g., oak-hickory forest). We collected data from 55 plots during the 2001 field season and an additional 8 plots during the 2002 accuracy assessment field season (Figure 24).

Table 4. Cover scales for strata and species.

Strata Cover Classes		Species Cover Classes	
Code	***Range of Class***	***Code***	***Range of Class***
01	01-<10%	01	0 -<1%
02	10-<25%	02	1-<5%
03	25-<60%	03	5-<25%
04	60-100%	04	25-<50%
		05	50-<75%
		06	75-100%

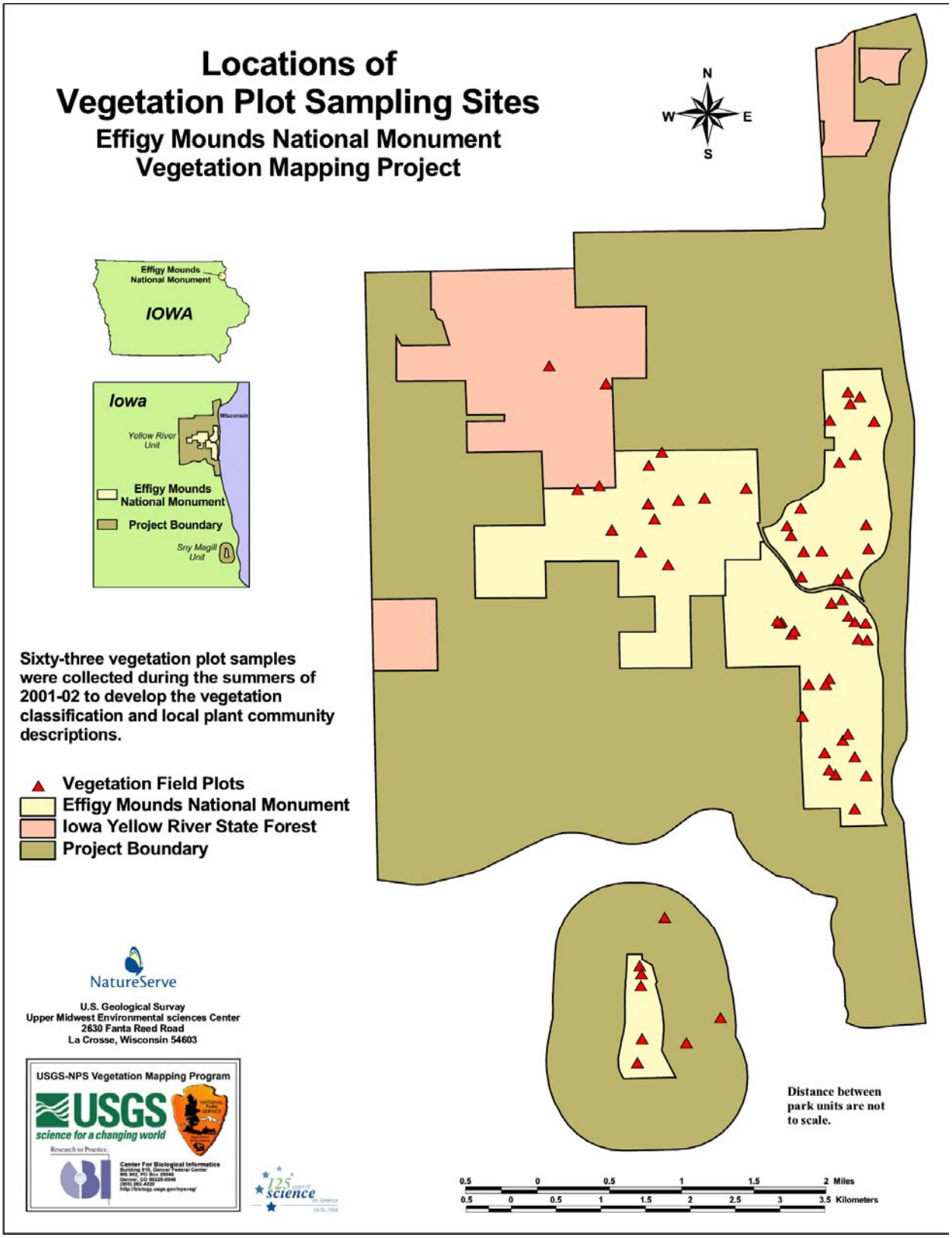


Figure 24. Locations of vegetation plot sampling sites.

Several environmental variables, including plot elevation, topographic position, slope aspect, slope angle, surficial geology, hydrologic regime, and soil information were sampled to characterize the local conditions. Comments about features relevant to the plot were also recorded (see Appendix B: Example of a Plot Sampling Form).

We entered the plot data into the PLOTS Database System (TNC 1997) at UMESC for subsequent data analyses. We also produced a spatial database of the vegetation plot locations with plant community information describing the sites for use in GIS. Also, the field data are included on the project's PLOTS Database.

Data Analyses and Results

The analyses of plot data matched our preliminary classification based on the NVCS for the Midwest (NatureServe 2003a), information from Iowa Natural Areas Inventory (J. Pearson, Iowa Department of Natural Resources, Des Moines, personal communication), and earlier work done in the region (Cahayla-Wynne and Glenn-Lewin 1978, Glenn-Lewin et al. 1984). The analyses also indicated some refinements, especially for areas affected by the impoundments. All these changes were incorporated into the NVCS plant community database (NatureServe 2003a).

To analyze vegetation patterns and classify types, we partitioned the plot data using ordination and clustering techniques with PC-ORD 4.0 software (McCune and Mefford 1999). The initial grouping on plots was based on a distinction between primarily wetland and primarily upland plots (Figure 25). The wetland set of plots was further subdivided based on the predominance of woody (tree or shrub) versus herbaceous species. Within the herbaceous wetland, subsequent analyses separated deep marshes and submergent/emergent dominated aquatic communities from shallow marshes and wet meadows. Those plots then were linked to NVCS plant communities (associations) based on the dominant species composition (not shown). Woody species dominating wetlands were divided into floodplain forests and wet shrublands. Analyses showed the floodplain forests could be further divided into those dominated by silver maple (*Acer saccharinum*) and those dominated by green ash (*Fraxinus pennslyvanica*). Wet shrublands were linked to the NVCS based on dominant shrub species.

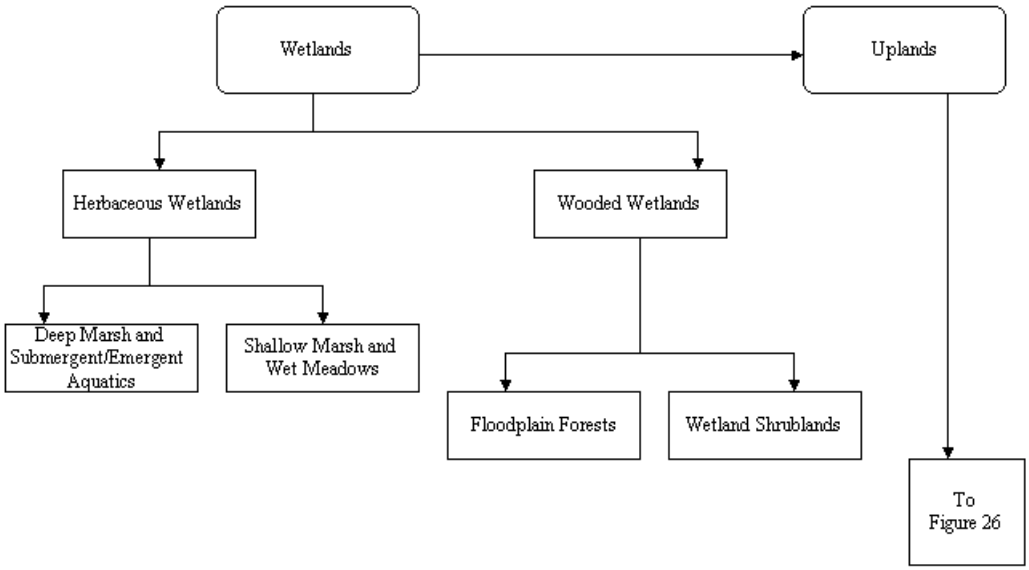


Figure 25. Ordination and cluster analysis of wetland vegetation types.

We analyzed the upland communities similarly using ordination and clustering. We found most of the upland herbaceous communities associated with restoration prairie plots. We could easily separate these prairie communities from forested communities and assigned them to an NVCS association type based on the predominate prairie community listed for this area of Iowa (NatureServe 2003a). Our analyses of the woodlands and forests showed a distinction between the dry to dry-mesic forests and woodlands and those that were more mesic to wet-mesic (Figure 26). Because of disturbances such as logging or grazing, however, distinctions between the communities within these two groupings were too subtle to be easily distinguished. To better present the results of the ordination and cluster analyses, we calculated the constancy and frequency of all the overstory and understory species associated with all the plots in each grouping (dry/dry-mesic and mesic/wet-mesic). We used these to further characterize and differentiate the different forest types. From these analyses, we could delineate four forest and woodland NVCS associations. The drier types contained a higher frequency of white oak (*Quercus alba)* and understory species commonly associated with dry woodlands (e.g. *Carex* spp.) and included a woodland dominated by Chinquapin oak (*Q. muhlenbergii*) and eastern redcedar (*Juniperus virginiana*), and a forest type dominated by white oak (*Q. alba*), northern red oak (*Q. rubra*), and shagbark hickory (*Carya ovata*). More mesic types contained a higher frequency of sugar maple (*A. saccharum*) and a higher proportion of spring ephemerals and mesic understory species such as *Laportea canadensis*. The two mesic forest types included the matrix forest for this region, sugar maple - basswood, and a more upland example of the green ash forest also associated with the floodplain.

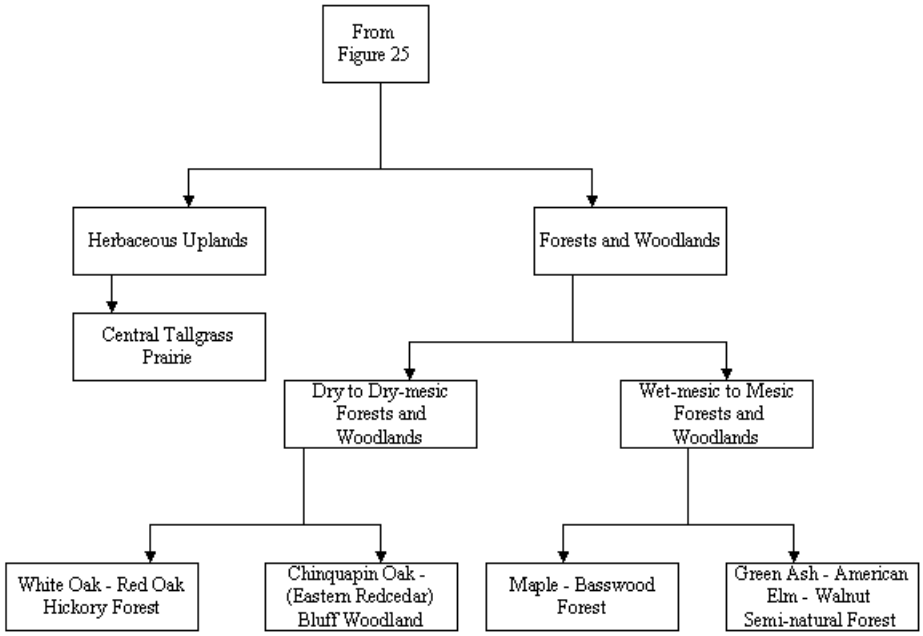


Figure 26. Ordination and cluster analysis of upland vegetation types.

Through the analyses of the 63 plot samples collected, we resolved 15 plant communities for EFMO and wrote plant community descriptions, both at the local and global scale. We identified two more plant communities from our accuracy assessment field data, but provided only global descriptions because of the lack of sampling data for adequate analyses for local descriptions. In Table 5 we list the 17 NVCS associations we identified and described for the EFMO Vegetation Mapping Project. We describe these 17 plant communities in Appendix C: Plant Community Descriptions of Effigy Mounds National Monument and supply a key to these plant communities in Appendix D: Dichotomous Keys to Plant

Communities of Effigy Mounds National Monument. We also list the plant species generated from the PLOTS Database in Appendix E: Plant Species List of Effigy Mounds National Monument.

Table 5. NVCS associations (plant communities) recognized at Effigy Mounds National Monument.

North-Central Interior Maple-Basswood Forest
Acer saccharum - *Tilia americana* / *Ostrya virginiana* - *Carpinus caroliniana* Forest
Fraxinus pennsylvanica - *Ulmus americana* - (*Juglans nigra*, *Celtis occidentalis*) Forest
North-Central Interior Dry-Mesic Oak Forest and Woodland
Quercus alba - *Quercus rubra* - *Carya ovata* Glaciated Forest
Paleozoic Plateau Bluff and Talus
Quercus muehlenbergii - *Quercus* (*alba, velutina*) - (*Juniperus virginiana* var. *virginiana)* Bluff Woodland
Central Tallgrass Prairie
Andropogon gerardii - *Sorghastrum nutans* - (*Sporobolus heterolepis*) - *Liatris* spp. - *Ratibida pinnata* Herbaceous Vegetation
North-Central Interior Floodplain
Acer saccharinum - *Ulmus americana* - (*Populus deltoides*) Forest
Populus deltoides - *Salix nigra* Forest
Salix interior Temporarily Flooded Shrubland
Cephalanthus occidentalis / *Carex* spp. Northern Shrubland
Phalaris arundinacea Eastern Herbaceous Vegetation
Schoenoplectus fluviatilis - *Schoenoplectus* spp. Herbaceous Vegetation
Schoenoplectus tabernaemontani - *Typha* spp. - (*Sparganium* spp., *Juncus* spp.) Herbaceous Vegetation
Sagittaria latifolia - *Leersia oryzoides* Herbaceous Vegetation
Potamogeton spp. - *Ceratophyllum* spp. Midwest Herbaceous Vegetation
Nelumbo lutea Herbaceous Vegetation
Nuphar lutea ssp. *advena* - *Nymphaea odorata* Herbaceous Vegetation
River Mud Flats Sparse Vegetation

Grouped by Ecological System units (in bold).

Vegetation Mapping

Methods

Our process of mapping vegetation and land use of EFMO and environs involved four primary steps, (1) field reconnaissance, (2) map classification, (3) photointerpretation, and (4) digital map automation and database development.

Field Reconnaissance

We visited EFMO the day after acquiring the October 9, 2000 aerial photographs. Our purpose was to observe leaf phenology as close as possible to the date of photography. We did not have the aerial photos in hand, so we took notes and digital pictures of various tree species in their differing phenology stages (Figure 27). When we received the aerial photographs, we compared them to our notes.

Figure 27. Examples of leaf phenology conditions near the date of October aerial photography.

As Hershey and Befort (1995) explain, CIR photography is not consistent between photo sets to allow a species or type to be described precisely. Film batch, printing process, sun angle, light intensity, shadow, and exposure can all affect the appearance. Hence, even as experienced photointerpreters, we engaged in formal ground verification of our aerial photographs. Field reconnaissance helped us correlate vegetative photo signatures (appearances of vegetation on the aerial photographs) to vegetation on the ground. Field reconnaissance allowed us to become more familiar with the local ecology as well, which is important when we apply ecological concepts to our photointerpretation mapping.

We began our first formal field reconnaissance in July 2001 when we investigated ground conditions with the aerial photos. We combined this field exercise with our vegetation reconnaissance, an effort of exploring and validating plant communities. This field effort gave us our first look at how vegetation types appear on the aerial photographs, and provided us perspective for planning our vegetation sampling effort.

During October 2001, we continued our field efforts for mapping, gaining better understanding of vegetation types and how they appear on the aerial photos. October's fieldwork proved invaluable as the vegetative conditions were relatively the same as the date of photography the prior year (Figure 28). This helped us determine which trees species were generally senescing out, giving various color and tone appearances on the aerial photographs.

Figure 28. Vegetation mappers performing additional fieldwork to establish map classification and mapping protocols.

During our reconnaissance, we became familiar with the vegetation and local ecology. We discussed the structural, floristic, and habitat characteristics of the vegetation encountered in the field and compared them to their appearance on the photos. Through this process, we built an understanding of how to map the vegetation types (or anticipated types). We collected ground data from numerous observation field reconnaissance sites to verify vegetation types and document relations between field and aerial photo perspectives (see Figure 29 for locations). Ground coordinates were collected using Garmin III+ global positioning system (GPS) receiver. We completed formal data sheets, which included the field participants, location information (including GPS coordinates), aerial photo relations (including photo signatures), ground survey of dominant plants, classification, digital pictures, and general observations and discussions about the site (see Appendix F: Example of an Observation Field Reconnaissance Form). We documented numerous other less formal notes on the aerial photo's protective sleeves as we continued our field efforts to learn what was there, then test and validate our initial findings. We used both our formal and informal field data, along with our ecological understanding of the vegetation types at that time, to establish the map classification and mapping protocols.

We produced a spatial database set of our formal reconnaissance sites (those seen in Figure 29) for use in GIS with locations, map classification, and link to associated plant communities.

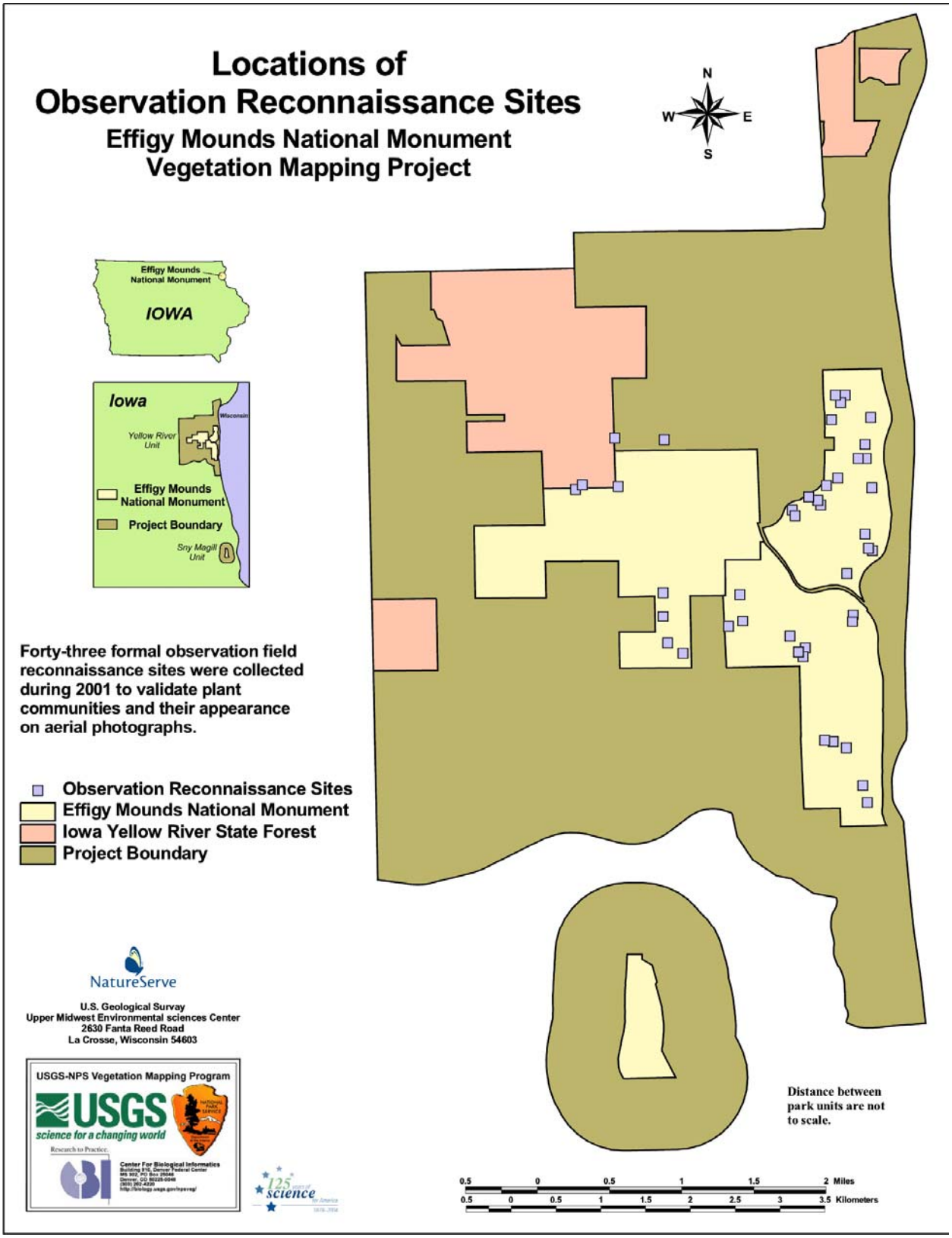


Figure 29. Locations of formal observation field reconnaissance sites.

Map Classification

Our ultimate goal with a map classification was to represent the plant communities of EFMO as defined with this project. Map codes are derived for ease of assigning information to map polygons.

With VMP projects, the goal is to map the finest level of the NVCS, which is the association (plant community). The relation of a map class to a plant community can be complex. What we see on the photographs is not necessarily what defines the plant community. Often, for instance, we are unable to map plant communities independently of each other because of the difficulty of differentiating floristic components on the aerial photographs. Consequently, we map those communities together as one map class. With EFMO, however, we find the opposite. In specific cases, we were able to map recurring variations of some plant communities. We developed map class phases when a variation of the plant community was recognizable on the aerial photographs and had importance for either management or ecological interests. For example, park biologists are interested in the locations of remnant bur oak stands. Remnant bur oak stands are part of the silver maple bottomland forest plant community and we knew of their locations. Thus, we set out to map these bur oak stands as a phase so stand locations could be differentiated from the more ubiquitous stands dominated by silver maple trees. The features we use to develop map class phases of plant communities do not necessarily meet criteria for defining a separate plant community.

Our map classification and protocols are based on existing classification systems. Identifying the relations between the map and vegetation classifications continued throughout the entire project. Map classes representing natural/semi-natural plant communities are linked to NVCS associations as identified by NatureServe. Some vegetation types could not be assigned to a plant community because of disturbance (e.g., fallow fields of shrubs and forbs). For those map classes, we assigned the appropriate NVCS Formation type. For non-vegetated features (e.g., roads, urban areas, non-vegetated bodies of water), we derived map classes corresponding closely with Anderson et al. (1976) Level II land cover and land use classification.

Map classification and mapping protocols underwent several revisions during field efforts and lab analyses. Once we completed the initial vegetation sampling analyses early spring 2002, we made additional modifications to our map classification and protocols. Although our final analyses of vegetation samples were incomplete, we went forward with the mapping in preparation for the accuracy assessment field season scheduled for summer 2002. Toward the end of the project, we adjusted the map classification as needed to best reflect the vegetation classification.

For those map classes representing plant communities, we used NatureServe's synonym name (e.g., Water Lily Aquatic Wetland). For map classes with phases, we used NatureServe's synonym name followed by the phase name in parenthesis, such as Midwestern White Oak - Red Oak Forest (oak - hickory phase). For map classes representing NVCS Formation types and non-vegetated features, we derived generic names typically describing the vegetation and landscape.

As mentioned earlier, we derived codes for ease of classifying map polygons. For each polygon, a map attribute code is assigned, which is a code constructed of two sections, a single map class code and a set of physiognomic modifier codes. A map class code is made up of three alpha characters and represents an independent map class. Each map class code begins with first letter of the NVCS Class it represents (F for Forest/Woodland, S for Shrubland, and H for Herbaceous Vegetation). For non-vegetated features, map class codes begin with first letter of the project defined category (O for Open Water and L for Land Use). The subsequent two alpha characters loosely represent the map class description (e.g., OH for oak-hickory, US for upland scrub, RR for road and railroad).

Physiognomic modifier codes are strings of alpha and numeric characters and, if applicable, they follow the map class codes. A hyphen separates the two code systems. These physiognomic modifiers provide additional information describing the physiognomic characteristics of the vegetation within each mapped polygon. The coverage density, coverage pattern, and height physiognomic modifiers are standard to

VMP projects. The oak forest component modifier, which we applied to one particular map class phase, is project specific to benefit EFMO resource management. Table 6 lists all standard and project specific physiognomic modifiers.

Table 6. Physiognomic modifiers assigned to polygons during photointerpretation.

Category	Modifier	Meaning
Coverage density (Applied to all vegetation map classes)	1 2 3	Closed Canopy/Continuous (60-100% cover) Open Canopy/Discontinuous (25-60% cover) Dispersed-Sparse Canopy (10-25% cover)
Coverage pattern (Applied to all vegetation map classes)	A B C D	Evenly Dispersed Clumped/Bunched Gradational/Transitional Regularly Alternating
Height (Applied to woody terrestrial vegetation map classes only)	2 3 4	15-30 m (50-98 ft) 5-15 m (16-50 ft) 0.5-5 m (1.5-16 ft)
Oak Forest Component (Applied to the FOH map class only)	Q M	Oak >75% relative dominance Oak 25-75% relative dominance

An example of a map attribute code is “FOH-1A2Q” describing the oak-hickory phase of the Midwestern White Oak - Red Oak Forest plant community, with coverage density of from 60 to 100%, coverage pattern evenly distributed, average tree height within the polygon of from 15 to 30 m (50 to 98 ft), and >75% relative cover of oak trees.

Having this series of map classification and physiognomic modifiers can greatly enhance the interpretation of the map coverage. For example, an oak-hickory forest plant community can be identified as high quality with a map attribute code of FOH-1A2Q. In contrast, a poor quality of the same plant community can be identified with a map attribute code of FBA-2B3, which describes the a dominance of bigtooth aspen phase (tree dominance of bigtooth aspen indicating disturbance in recent history), with coverage density of from 25 to 60%, coverage pattern clumped/bunched, and average tree height of from 5 to 15 m (16 to 50 ft).

Photointerpretation

Choice of Aerial Photographs for Mapping: We chose the October set of aerial photos for our primary mapping because of larger scale resolution and leaf phenology conditions of fall. We used one photo from the August set to map a section the October set did not cover (an area added to the map effort post photo mission). We used the remaining August-dated photos as an aid in mapping the October set. Having two sets of photographs acquired at different dates and scales were helpful in the photointerpretation process. The August set of photos showed peak vegetation biomass, particularly useful in distinguishing emergent and macrophytic wetlands. With the October set, some of the deep aquatic wetland plants had senesced beyond recognition (see figure 30 for comparison). However, deciduous trees are not readily identifiable on the August photos due to the same biomass peak condition. The October date of photos enabled us to better recognize deciduous forest types as leaf phenology of different tree species were changing at different times.

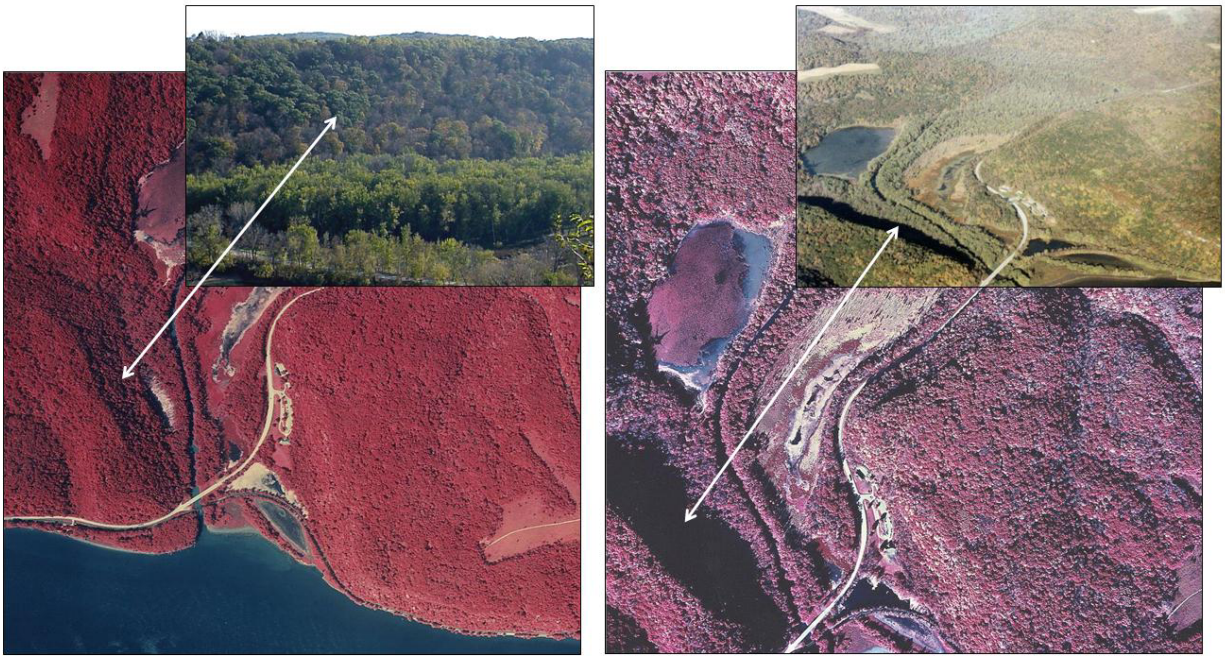
As expected with October-dated aerial photography, large shadows are evident on the steeper northern-aspect hillsides where the sun angle was low to the south at this geographic latitude. The August-dated photography offered less shadow with the mid-summer sun angle more directly above (see figure 31 for

comparison). Again, we used the August photo set to help us determine vegetation and landscape in area of shadow on the October photographs.

August 2000 aerial photo showing clear evidence of arrowhead vegetation.

October 2000 aerial photo showing little evidence of arrowhead vegetation.

Figure 30. Macrophytic wetland comparison between August 2000 and October 2000 aerial photographs.



August 2000 aerial photo showing very little shadow cast from steep north-facing hillside

October 2000 aerial photo showing shadow cast from steep north-facing hillside

Figure 31. Shadow comparison between August 2000 and October 2000 aerial photographs.

Aerial Photointerpretation Mapping: Preparation of the aerial photographs for interpretation generally followed procedures of Owens and Hop (1995). We placed clear acetate overlays on each aerial photograph transparency used for mapping. Using the positive transparency photos for photointerpretation provided us with the highest resolution possible and they are dimensionally stable (made of Estar base). The paper contact prints are less desirable because they are grainier and the paper base can expand and contract slightly with changes in temperature and humidity.

We registered each overlay to the photos by the fiducials (standard reference points) and photo identification information. We viewed the photos for interpretation using a light table and Topcon M-3 mirror stereoscope with 3X and 6X binoculars (Figure 32). We paired up each transparency photo with the adjacent photo so we could view the images 3-dimensionally. Normally we used the middle portion of each photograph for the photointerpretation data to minimize edge distortion. On occasion, we needed to map closer to the photo edges in order to reach the extend map boundary. We delineated feature polygons and scribed their corresponding map class codes onto the acetate overlays using Rapidograph ink pens.

Figure 32. Topcon stereoscope equipment for photointerpretation mapping.

We typically drew larger polygons first and followed with smaller polygons down to the MMU guidelines. In applying MMU, we tended to err below the guideline rather than above given the nonrectified aerial photos have inherent in them angle distortions and slight scale changes from high ridges to valley bottoms. We applied standard photo signature characteristics, including texture, color, pattern, and position in the landscape to guide placement of the drawn polygon. In addition to photo signature characteristics, knowledge of the environmental distribution of the types helped us to identify vegetation types and properly place polygon boundaries. For each polygon, we applied the appropriate map class code and physiognomic modifier codes.

We used canopy crown size, relative dominance of individual tree species, and patchiness of canopies as criteria for distinguishing forested-type map classes. We also used 1940 and 1960 black and white aerial photos developed for Narumalani et al. (2002) to help determine historic land use and understand successional patterns. For instance, lands cleared for pasture returned with a stronger component of oak, whereas lands both cleared and plowed were less populated with oak.

We engaged in a map validation effort April 2002 to test the photointerpretation and application of the map classification. Looking for repeatable inconsistencies, only minor adjustments were needed, mostly to the height physiognomic modifier.

Digital Map Automation and Database Development

Digital Mapping: We converted the photointerpreted data into a GIS-usable format using three fundamental processes; (1) geo-reference, (2) digitize, and (3) database enhancement. The resulting map products are two ArcInfo coverages (the Yellow River Unit and environs and the Sny Magill Unit and environs), each projected in UTM, Zone 15, using NAD83.

Geo-reference: We geo-referenced the interpreted overlays using OrthoMapper (Image Processing Software Inc., Madison, Wisconsin), a softcopy photogrammetric software for GIS. OrthoMapper is a computer program designed to create orthophotographs from scanned and unrectified photographs (Image Processing Software, Inc. 2002). The software features a method of visual orientation involving a point-and-click operation using existing geo-referenced horizontal and vertical base maps. OrthoMapper also has the capability to geo-reference photo interpreted overlays, which is of primary importance to us. Interpreted overlays are geo-referenced using the orthophotographs produced from the OrthoMapper software.

First, we scanned each aerial photograph at 400 dots per inch (dpi) and 64 million colors, producing a series of Tagged Image File Format (TIFF) images. We then used OrthoMapper to register each image establishing both horizontal and vertical coordinates. Table 7 lists each USGS 3.75-minute digital orthophoto quadrangle (DOQ) image we used to derive the horizontal coordinates of the aerial photo image. Table 8 lists each USGS 7.5-minute digital elevation model (DEM) we used to derive the vertical coordinates of the aerial photo image. Once orthophotos were made, we scanned each overlay of photointerpreted data at a resolution of 100 dpi and black and white, again producing a series of TIFF images. Again, we used Orthomapper to register each overlay image, this time to their corresponding orthophoto just produced. Finally, we mosaicked the geo-referenced overlay images into workable groups (e.g., 15–20 overlays) for subsequent digitizing (three groups for the Yellow River Unit and one for Sny Magill Unit).

Table 7. List of USGS 3.75-minute DOQ images to register aerial photo horizontal coordinates.

USGS Quadrangle	Source Photo Date	Resolution (m)	Map Coverage
Clayton NE	5/17/1994	10	Sny Magill
Clayton SE	5/17/1994	10	Sny Magill
Harpers Ferry SE	5/17/1994	10	Yellow River
Harpers Ferry SW	5/17/1994	10	Yellow River
Prairie du Chien NE	5/17/1994	10	Yellow River
Prairie du Chien NW	5/17/1994	10	Yellow River
Prairie du Chien SE	5/17/1994	10	Yellow River
Prairie du Chien SW	5/17/1994	10	Yellow River

Table 8. List of USGS 7.5-minute DEM grids to register aerial photo vertical coordinates.

USGS Quadrangle	Source Date	Publication Date	Resolution (m)	Map Coverage
Clayton	1958	9/12/2001	10	Sny Magill
Harpers Ferry	1980	9/17/2001	30	Yellow River
Prairie du Chien	1983	9/17/2001	10	Yellow River

Digitize: To produce polygon vector coverages for use in GIS, we converted the raster-based image mosaics of geo-referenced overlays containing the photointerpreted data into a grid format using ArcInfo (Version 8.0.2, Environmental Systems Research Institute, Redlands, California). In ArcTools, we used the ArcScan utility to trace the polygon data and produced ArcInfo vector-based coverages. We digitally assigned map attribute codes (both map classes and physiognomic modifiers) to the polygons, and checked the digital data against the photointerpreted overlays for line and attribute consistency. Lastly, we merged the three Yellow River Unit coverages. Ultimately, we generated two seamless vegetation map coverages (the Yellow River Unit and environs and the Sny Magill Unit and environs).

Database Development: At this stage, the map coverages have mere map attribute codes assigned to each polygon. To assign a set of meaningful information to the map coverages (e.g., as map class names, physiognomic definitions, link to NVCS level types), we joined an attribute table containing this information to each map coverage. We produced the attribute tables in spreadsheet format (dBASE IV) with information relating to the attribute items listed in Table 9. We converted the dBASE IV table into an ArcInfo table, then joined the attribute table to the spatial database coverage's table using the MAP_ATT item as the common attribute item. In addition to the attribute items listed in Table 9, ArcInfo default items are also included in the final map coverage (e.g., perimeter, area, and polygons identification numbers). We used ArcInfo to produce the ArcInfo Export and Spatial Data Transfer Standard files of the map coverages.

Table 9. Map attribute items of the vegetation map coverage database table.

Map Item	Map Item Description and Example
MAP_ATT	Map Class code with all applicable Physiognomic Modifier codes (project derived) Example: FOH-1A2M
MAP_CLASS	Map Class code (project derived) Example: FOH
MAP_DESC	Full Map Class name, Base and Phase names together (project derived) Example: Midwestern White Oak - Red Oak Forest (oak-hickory phase)
MAP_BDESC	Base Map Class name (project derived) Example: Midwestern White Oak - Red Oak Forest
MAP_PDESC	Phase Map Class name (project derived) Example: oak-hickory phase
DENS_MOD	Coverage Density Physiognomic Modifier (VMP standard) Example: 1 - Closed Canopy/Continuous (60-100% coverage)
PTRN_MOD	Coverage Pattern Physiognomic Modifier (VMP standard) Example: A - Evenly Dispersed
HT_MOD	Height Physiognomic Modifier (VMP standard) Example: 2 - 15-30 meters (50-98 feet)
DOM_MOD	Oak Component (project derived) Example: M - Oak 25-75% relative dominance
ECO_SYSTEM	Ecological System (NatureServe 2003b) Example: North-Central Interior Dry-Mesic Oak Forest and Woodland
ASSN_CEGL	Community Element Global code (NatureServe 2003a) Example: CEGL002068
ASSN_NAME	National Vegetation Classification System Association scientific name (NatureServe 2003a) Example: Quercus alba - Quercus rubra - Carya ovata Glaciated Forest
ASSN_CNAME	National Vegetation Classification System translated Association common name (NatureServe 2003a) Example: White Oak - Northern Red Oak - Shagbark Hickory Glaciated Forest
ASSN_SNAME	National Vegetation Classification System Association synonym name (NatureServe 2003a) Example: Midwestern White Oak - Red Oak Forest
NVCS_CODE	National Vegetation Classification System code to Alliance level (FGDC 1997, NatureServe 2003a) Example: I.B.2.N.a.27
ALL_NAME	National Vegetation Classification System Alliance scientific code and name (NatureServe 2003a) Example: I.B.2.N.a.27 - QUERCUS ALBA - (QUERCUS RUBRA, CARYA SPP.) FOREST ALLIANCE
ALL_CNAME	National Vegetation Classification System translated Alliance common name (NatureServe 2003a) Example: White Oak - (Northern Red Oak, Hickory species) Forest Alliance
FORMATION	National Vegetation Classification System Formation code and name (FGDC 1997, NatureServe 2003a) Example: I.B.2.N.a - Lowland or submontane cold-deciduous forest
SUBGROUP	National Vegetation Classification System Subgroup code and name (FGDC 1997, NatureServe 2003a) Example: I.B.2.N - Natural/Semi-natural Cold-deciduous forest
GROUP	National Vegetation Classification System Group code and name (FGDC 1997, NatureServe 2003a) Example: I.B.2 - Cold-deciduous forest
SUBCLASS	National Vegetation Classification System Subclass code and name (FGDC 1997, NatureServe 2003a) Example: I.B - Deciduous forest
CLASS	National Vegetation Classification System Class code and name (FGDC 1997, NatureServe 2003a) Example: I - Forest
LUC_II	USGS Land Use and Land Cover Classification System code and name (Anderson et al. 1976) Example: 41 - Deciduous Forest Land

Results and Discussion

Map Classes

We developed 47 map classes (including map class phases) to map EFMO and environs (Table 10). Of these, 30 map classes directly represent 16[1] NVCS plant communities (associations) as described by NatureServe. This almost 2:1 ratio of map class units to plant community types is due to variations in five of the plant communities. We could recognize these versions on the aerial photographs and considered them to be important for either management or ecological interests (providing useful information the plant community level could not provide). As a result, 19 map classes represent phases to 1 of 5 particular plant communities and 11 map classes each represent a single plant community. For the most part, the phase classes of forest types reflect disturbance history. We used canopy crown size, relative dominance of individual tree species, and patchiness of canopies as criteria to distinguish forested-type map class phases from one another. From this information, map users can distinguish between older and younger stands, and gain a sense of the degree of disturbance[1]. We developed six map class phases to describe the North-central Maple - Basswood Forest community, five phases for the Midwestern White Oak - Red Oak Forest, two phases for the Chinquapin Bluff Woodland, and four phases for the Silver Maple - Elm - (Cottonwood) Forest. For the two map class phases representing the Arrowhead - Rice Cutgrass Marsh plant community, we used dominance of arrowhead or rice cutgrass to determine the map class phase with which to classify.

Another 9 map classes represent 10 vegetation units at the Formation level of the NVCS, depicting both natural/semi-natural (n = 6 Formation types mapped with six map classes) and planted/cultivated (n = 4 Formation types mapped with 3 map classes) vegetation units. Although seven of the plant community types fall under three of these Formation types, we needed to develop additional map classes to define vegetation units neither meeting NVCS classification criteria at the plant association level nor criteria for alliance level (e.g., fallow field, crop field, pine plantation).

We derived an additional eight map classes to represent open water (<10% vegetated) and land use. These map classes by and large follow the descriptions as defined by Anderson et al. (1976) land use and land cover classification. Three map classes pertain to open water, and the other five to general land use.

Also, denoted with a double asterisk (**) in Table 10 are map classes to which we purposely applied an MMU of 0.1 ha (0.25 acres). For all other map classes we applied an MMU of 0.25 ha (0.62 acres). It is worth mentioning at this point that, from a quick and informal study of the map coverage tables, our decision to err mapping below MMU to account for distortions and slight scale changes inherent on the aerial photos is apparent. Most map classes have polygons mapped below MMU.

Table 10. Map classification for the Effigy Mounds National Monument Vegetation Mapping Project.

Map Code	Map Class Name	NVCS X-Walk Code	YLW	SNY
NVCS PLANT COMMUNITY (ASSOCIATION) CLASSES				
North-Central Interior Maple-Basswood Forest				
-	North-central Maple - Basswood Forest	I.B.2.N.a.8.002062	-	-
FOM	*east-facing maple phase*		x	x
FMB	*north-facing maple phase*		x	x
FNO	*north-facing red oak phase*		x	
FOX	*disturbed oak phase*		x	x
FOB	*disturbed maple - basswood phase*		x	x
FMH	*disturbed hardwoods phase*		x	x
FRH	Ash - Elm - Walnut - Hackberry Semi-natural Forest	I.B.2.N.a.47.005239	x	x
North-Central Interior Dry-Mesic Oak Forest and Woodland				
-	Midwestern White Oak - Red Oak Forest	I.B.2.N.a.27.002068	-	-
FWO	*white oak - chinquapin oak phase** **		x	x
FOH	*oak - hickory phase*		x	x
FSH	*shagbark hickory phase*		x	x
FBA	*bigtooth aspen phase*		x	x
FTA	*trembling aspen phase***		x	
Paleozoic Plateau Bluff and Talus				
-	Chinquapin Oak Bluff Woodland		-	-
FRC	*red-cedar phase***	II.B.2.N.a.21.002144	x	
FHP	*hillside prairie phase***	II.B.2.N.a.21.002144	x	x
Central Tallgrass Prairie				
HRP	Central Mesic Tallgrass Prairie	V.A.5.N.a.2.002203	x	
North-Central Interior Floodplain				
-	Silver Maple - Elm - (Cottonwood) Forest	I.B.2.N.d.4.002586	-	-
FMC	*maple phase*		x	x
FEH	*hackberry phase*		x	x
FSW	*swamp white oak phase*		x	
FBO	*bur oak phase*			x
FCW	Eastern Cottonwood - Black Willow Forest	I.B.2.N.d.15.002018	x	x
SWL	Sandbar Willow Shrubland	III.B.2.N.d.6.008562	x	
SBB	Northern Buttonbush Swamp	III.B.2.N.f.1.002190	x	x
HCG	Reed Canary Grass Eastern Marsh	V.A.5.N.k.20.006044	x	x
HRB	River Bulrush Marsh	V.A.5.N.k.26.002221	x	
HGB	Bulrush - Cattail - Burreed Shallow Marsh	V.A.5.N.k.33.002026	x	
-	Arrowhead - Rice Cutgrass Marsh	V.B.2.N.e.7.005240	-	-
HRC	*rice cutgrass phase*		x	x
HBA	*arrowhead phase*		x	
HPW	Midwest Pondweed Submerged Wetland	V.C.2.N.a.14.002282	x	x
HAL	American Lotus Aquatic Wetland	V.C.2.N.a.100.004323		x
HWL	Water Lily Aquatic Wetland	V.C.2.N.a.102.002386	x	x

Map Code	Map Class Name	NVCS X-Walk Code	YLW	SNY
NVCS FORMATION TYPE CLASSES				
Upland Shrubland and Herbaceous Vegetation				
SUS	Upland Scrub Mix	III.B.2.N.a	x	
HUF	Upland Herbaceous Mix	V.A.5.N.a	x	x
HGP	Goat Prairie Remnant**	V.A.5.N.c	x	
Wetland Herbaceous Vegetation				
HBF	Bottomland Herbaceous Mix	V.A.5.N.j	x	x
HEP	Emergent Marsh Farm Pond**	V.A.5.N.k	x	
HSP	Submersed Aquatic Farm Pond**	V.C.2.N.a	x	
Forest Plantation				
FCP	Conifer Plantation Forest	I.A.8.C.a	x	
Pasture and Cropland				
HPG	Perennial Grass Crop	V.A.5.C.a	x	x
HCF	Crop Field	V.D.2.C.a/V.D.2.C.b	x	x
NON-VEGETATION CLASSES				
Open Water				
OFP	Open Water Farm Pond**	N/A	x	
OSM	Shallow Water and Mud Flat	N/A	x	x
ORS	River and Stream	N/A	x	x
Land Use				
LRS	Residential	N/A	x	
LCM	Commercial	N/A	x	
LRR	Road and Railroad	N/A	x	x
LFB	Farmstead	N/A	x	x
LQR	Quarry	N/A		x

** The white oak - chinquapin oak phase map class phase (FWO) maps in part Chinquapin Oak Bluff Woodland (II.B.2.N.a.21.002144) due to limitations in recognizing this class on the aerial photographs.*

*** Designated MMU of 0.1 ha (0.25 acres).*

Map Classes Representing NVCS Plant Communities (by Ecological System units)

We grouped the 30 map classes representing NVCS plant communities (associations) into 5 Ecological System (ES) units derived by NatureServe (2003b) and Comer et al. (2003). The concept of ES units is discussed earlier in this report. Map class names (minus any name referencing the phase) are synonymous with the NVCS plant community names as depicted by NatureServe (2003a).

North-central Interior Maple-Basswood Forests: This ES unit contains two primary map classes, North-central Maple - Basswood Forest and Ash - Elm - Walnut - Hackberry Semi-natural Forest. The North-central Maple - Basswood Forest map class is split into six phases, three depicting high-quality forests (east-facing maple, north-facing maple, and north-facing red oak phases), and three depicting forest disturbance (disturbed oak, disturbed maple - basswood, and disturbed hardwoods phases).

North-central Interior Dry-Mesic Oak Forest and Woodland: This ES unit has one primary map class, Midwestern White Oak - Red Oak Forest. With five phases, two indicate high-quality forests (white oak - chinquapin oak, oak - hickory phases) and the other three indicate disturbance (shagbark hickory,

bigtooth aspen, and trembling aspen phases). We mapped the white-oak - chinquapin oak, bigtooth aspen, and trembling aspen phases with an MMU of 0.1 ha (0.25 acres).

Paleozoic Plateau Bluff and Talus: This ES unit has one primary map class, Chinquapin Oak Bluff Woodland. Two phases split the map class (red-cedar and hillside prairie phases). We mapped both these phases with an MMU of 0.1 ha (0.25 acres).

Central Tallgrass Prairie: This ES unit has one primary map class, Central Mesic Tallgrass Prairie. This map class depicts the prairie grassland units EFMO has seeded and managed with prescribed burns.

North-Central Interior Floodplain: This ES unit has 11 primary map classes. The Silver Maple - Elm - (Cottonwood) Forest map class is split into four phases (maple, hackberry, swamp white oak, and bur oak phases) to depict the dominance or presence of particular tree species. The Arrowhead - Rice Cutgrass Marsh map class is split into two phases (rice cutgrass and arrowhead phases). The remaining map classes are the Eastern Cottonwood - Black Willow Forest, Sandbar Willow Shrubland, Northern Buttonbush Swamp, Reed Canary Grass Eastern Marsh, River Bulrush Marsh, Bulrush - Cattail - Burreed Shallow Marsh, Midwest Pondweed Submerged Wetland, American Lotus Aquatic Wetland, and Water Lily Aquatic Wetland.

Map Classes Representing NVCS Formation Types (by NVCS Formation groups)

Because a plant community could not be defined or the vegetation did not fit the concept of plant community (e.g., planted/cultivated types), we needed to develop map classes representing NVCS Formation types. We categorized those map classes into four groupings.

Upland Shrubland and Herbaceous Vegetation: This Formation grouping consists of Upland Scrub Mix, Upland Herbaceous Mix, and Goat Prairie Remnant map classes, each representing a type at the Formation level. We are recognizing the Goat Prairie Remnant at the Formation level because the small size inhibited our defining a plant community. All of these map classes are natural/semi-natural Formation types. The Goat Prairie Remnant map class is mapped with an MMU of 0.1 ha (0.25 acres).

Wetland Shrubland and Herbaceous Vegetation: This Formation grouping consists of Bottomland Herbaceous Mix, Emergent Marsh Farm Pond, and Submersed Aquatic Farm Pond map classes, each representing a type at the Formation level. All of these map classes are natural/semi-natural Formation types. The two farm pond map classes are mapped with an MMU of 0.1 ha (0.25 acres).

Forest Plantation: This Formation grouping consists of the Conifer Plantation Forest map class. It represents one planted/cultivated Formation type.

Pasture and Cropland: This grouping consists of Perennial Grass Crop and Crop Field map classes. The Perennial Grass Crop map class describes pastureland and represents one planted/cultivated Formation type. The Crop Field map class describes row crops (e.g., corn, soybeans) and close-grown crops (e.g., alfalfa) and represents two planted/cultivated Formation types.

Map Classes Representing Non-vegetation Units

Two non-NVCS categories describe open water and land use features. These map classes are defined largely after the USGS land cover and land use classification system developed by Anderson et al. (1976).

Open Water: The open water map classes can actually have up to 10% vegetation. Because of the difficulty in distinguishing water bodies with no vegetation from bodies with sparse vegetation (<10%), both scenarios were mapped as *open water*. We developed three map classes to describe open water situations, Open Water Farm Pond, Shallow Water and Mud Flat, and River and Stream. Open Water Farm Pond was mapped with an MMU of 0.1 ha (0.25 acres).

Land Use: Five map classes were devised to describe general land use and artificial features. These five map classes are Residential, Commercial, Road and Railroad, Farmstead, and Quarry.

Map Classification Descriptions

In addition to providing descriptions to NVCS plant communities (Appendix C: Plant Community Descriptions of Effigy Mounds National Monument), we also developed map class descriptions. Our goals with these descriptions are to

- describe each map class from a photointerpretation perspective so the user may better understand how and why the map coverage was made,
- describe the link between each map class and the NVCS plant community it represents, and
- provide a ground photo image for each map class.

Appendix G: Map Classification Descriptions and Visual Guide gives descriptions to each map class we used in mapping EFMO and environs. This includes map classes (and their phases) representing NVCS plant communities, NVCS Formation types, and open water and land use classes.

Map Coverage Summary Report

Table 11 is a summary of the two vegetation map coverages. Again, the map classes are grouped under NatureServe's ES units. This summary shows frequency of polygons, area (in hectares), and average polygon size (in hectares) of the entire project area (both the Yellow River and Sny Magill Units and their respective environs). The columns in the table denoted with "ALL" reflect the combined coverage area. The columns denoted with "YLW" reflect the map coverage of the Yellow River Unit and those denoted with "SNY" reflect the map coverage of the Sny Magill Unit. We hoped to have provided an additional summary report of EFMO lands only. The existing park boundary coverage has inconsistencies, however, preventing an accurate summary. Using the present boundary coverage, small areas outside of EFMO would be committed (e.g., agriculture lands, railroads) and small areas of EFMO lands would be omitted, thus skewing the results in number of map classes, polygon frequency, and area. The NPS is making efforts to produce accurate park boundary coverages from ground surveys.

Table 11. Area report of the Effigy Mounds National Monument vegetation map coverage.

Map Code	Map Class Name	ALL Polygons	YLW Polygons	SNY Polygons	ALL Area Ha	YLW Area Ha	SNY Area Ha	ALL Ave Ha	YLW Ave Ha	SNY Ave Ha
North-Central Interior Maple-Basswood Forest										
FOM	North-central Maple - Basswood Forest (east-facing maple phase)	35	25	10	98.8	79.7	19.1	2.8	3.2	1.9
FMB	North-central Maple - Basswood Forest (north-facing maple phase)	102	97	5	190.2	185.5	4.7	1.9	1.9	0.9
FNO	North-central Maple - Basswood Forest (north-facing red oak phase)	64	64	0	53.9	53.9	0.0	0.8	0.8	0.0
FOX	North-central Maple - Basswood Forest (disturbed oak phase)	301	281	20	403.0	363.1	39.9	1.3	1.3	2.0
FOB	North-central Maple - Basswood Forest (disturbed maple - basswood phase)	193	192	1	247.0	246.6	0.5	1.3	1.3	0.5
FMH	North-central Maple - Basswood Forest (disturbed hardwoods phase)	378	346	32	759.9	715.1	44.7	2.0	2.1	1.4
FRH	Ash - Elm - Walnut - Hackberry Semi-natural Forest	60	57	3	64.9	58.7	6.2	1.1	1.0	2.1
	Sub Totals	*1,133*	*1,062*	*71*	*1,817.7*	*1,702.6*	*115.1*	*1.6*	*1.6*	*1.6*
North-Central Interior Dry-Mesic Oak Forest and Woodland										
FWO	Midwestern White Oak - Red Oak Forest (white oak - chinquapin oak phase)	96	95	1	32.3	31.7	0.6	0.3	0.3	0.6
FOH	Midwestern White Oak - Red Oak Forest (oak - hickory phase)	303	284	19	615.9	589.1	26.8	2.0	2.1	1.4
FSH	Midwestern White Oak - Red Oak Forest (shagbark hickory phase)	33	32	1	17.2	16.9	0.3	0.5	0.5	0.3
FBA	Midwestern White Oak - Red Oak Forest (bigtooth aspen phase)	142	139	3	52.2	51.6	0.6	0.4	0.4	0.2
FTA	Midwestern White Oak - Red Oak Forest (trembling aspen phase)	10	10	0	2.4	2.4	0.0	0.2	0.2	0.0
	Sub Totals	*584*	*560*	*24*	*720.0*	*691.7*	*28.3*	*1.2*	*1.2*	*1.2*
Paleozoic Plateau Bluff and Talus										
FRC	Chinquapin Oak Bluff Woodland (red-cedar phase)	26	26	0	3.5	3.5	0.0	0.1	0.1	0.0
FHP	Chinquapin Oak Bluff Woodland (hillside prairie phase)	71	65	6	8.5	8.0	0.5	0.1	0.1	0.1
	Sub Totals	*97*	*91*	*6*	*11.9*	*11.4*	*0.5*	*0.1*	*0.1*	*0.1*
Central Tallgrass Prairie										
HRP	Central Mesic Tallgrass Prairie	3	3	0	24.9	24.9	0.0	8.3	8.3	0.0
	Sub Totals	*3*	*3*	*0*	*24.9*	*24.9*	*0.0*	*8.3*	*8.3*	*0.0*
North-Central Interior Floodplain										
FMC	Silver Maple - Elm - (Cottonwood) Forest (maple phase)	117	75	42	302.9	140.0	162.9	2.6	1.9	3.9
FEH	Silver Maple - Elm - (Cottonwood) Forest (hackberry phase)	14	13	1	56.5	56.2	0.3	4.0	4.3	0.3
FSW	Silver Maple - Elm - (Cottonwood) Forest (swamp white oak phase)	1	1	0	0.3	0.3	0.0	0.3	0.3	0.0
FBO	Silver Maple - Elm - (Cottonwood) Forest (bur oak phase)	4	0	4	2.6	0.0	2.6	0.6	0.0	0.6
FCW	Eastern Cottonwood - Black Willow Forest	11	8	3	6.4	4.3	2.1	0.6	0.5	0.7

Map Code	Map Class Name	ALL Polygons	YLW Polygons	SNY Polygons	ALL Area Ha	YLW Area Ha	SNY Area Ha	ALL Ave Ha	YLW Ave Ha	SNY Ave Ha
SWL	Sandbar Willow Shrubland	13	13	0	3.6	3.6	0.0	0.3	0.3	0.0
SBB	Buttonbush Shrubland	4	3	1	2.9	2.0	0.9	0.7	0.7	0.9
HCG	Reed Canary Grass Eastern Marsh	71	51	20	75.2	64.7	10.4	1.1	1.3	0.5
HRB	River Bulrush Marsh	12	12	0	12.2	12.2	0.0	1.0	1.0	0.0
HGB	Bulrush - Cattail - Burreed Shallow Marsh	2	2	0	4.0	4.0	0.0	2.0	2.0	0.0
HRC	Arrowhead - Rice Cutgrass Marsh (rice cutgrass phase)	35	7	28	26.2	12.2	14.0	0.7	1.7	0.5
HBA	Arrowhead - Rice Cutgrass Marsh (arrowhead phase)	5	5	0	3.5	3.5	0.0	0.7	0.7	0.0
HPW	Midwest Pondweed Submerged Wetland	55	20	35	76.1	19.6	56.6	1.4	1.0	1.6
HAL	American Lotus Aquatic Wetland	5	0	5	4.0	0.0	4.0	0.8	0.0	0.8
HWL	Water Lily Aquatic Wetland	13	2	11	15.9	11.0	4.9	1.2	5.5	0.4
	Sub Totals	*362*	*212*	*150*	*592.3*	*333.5*	*258.8*	*1.6*	*1.6*	*1.7*
	NVCS Plant Community Map Classes Totals	***2,179***	***1,928***	***251***	***3,166.8***	***2,764.0***	***402.7***	***1.5***	***1.4***	***1.6***
NVCS FORMATION TYPE CLASSES										
Upland Shrubland and Herbaceous Vegetation										
SUS	Upland Scrub Mix	135	135	0	56.6	56.6	0.0	0.4	0.4	0.0
HUF	Upland Herbaceous Mix	110	107	3	126.1	124.4	1.7	1.1	1.2	0.6
HGP	Goat Prairie Remnant	8	8	0	0.6	0.6	0.0	0.1	0.1	0.0
	Sub Totals	*253*	*250*	*3*	*183.3*	*181.6*	*1.7*	*0.7*	*0.7*	*0.6*
Wetland Herbaceous Vegetation										
HBF	Bottomland Herbaceous Mix	28	22	6	28.8	25.2	3.6	1.0	1.1	0.6
HEP	Emergent Marsh Farm Pond	8	8	0	0.9	0.9	0.0	0.1	0.1	0.0
HSP	Submersed Aquatic Farm Pond	5	5	0	0.4	0.4	0.0	0.1	0.1	0.0
	Sub Totals	*41*	*35*	*6*	*30.1*	*26.5*	*3.6*	*0.7*	*0.8*	*0.6*
Forest Plantation										
FCP	Conifer Plantation Forest	14	14	0	9.8	9.8	0.0	0.7	0.7	0.0
	Sub Totals	*14*	*14*	*0*	*9.8*	*9.8*	*0.0*	*0.7*	*0.7*	*0.0*
Pasture and Cropland										
HPG	Perennial Grass Crop	147	140	7	488.9	474.9	13.9	3.3	3.4	2.0
HCF	Crop Field	74	65	9	604.4	559.7	44.7	8.2	8.6	5.0
	Sub Totals	*221*	*205*	*16*	*1,093.3*	*1,034.6*	*58.6*	*4.9*	*5.0*	*3.7*
	NVCS Formation Type Map Classes Totals	***529***	***504***	***25***	***1,316.4***	***1,252.5***	***63.9***	***2.5***	***2.5***	***2.6***
	All Vegetation Map Classes Totals	***2,708***	***2,432***	***276***	***4,483.2***	***4,016.5***	***466.7***	***1.7***	***1.7***	***1.7***

Map Code	Map Class Name	ALL Polygons	YLW Polygons	SNY Polygons	ALL Area Ha	YLW Area Ha	SNY Area Ha	ALL Ave Ha	YLW Ave Ha	SNY Ave Ha
NON-VEGETATION CLASSES										
Open Water										
OFP	Open Water Farm Pond	19	19	0	2.1	2.1	0.0	0.1	0.1	0.0
OSM	Shallow Water and Mud Flat	28	8	20	12.8	3.4	9.4	0.5	0.4	0.5
ORS	River and Stream	5	1	4	311.9	261.3	50.5	62.4	261.3	12.6
	Sub Totals	*52*	*28*	*24*	*326.8*	*266.8*	*59.9*	*6.3*	*9.5*	*2.5*
Land Use										
LRS	Residential	16	16	0	16.0	16.0	0.0	1.0	1.0	0.0
LCM	Commercial	5	5	0	15.5	15.5	0.0	3.1	3.1	0.0
LRR	Road and Railroad	13	10	3	86.5	68.9	17.6	6.7	6.9	5.9
LFB	Farmstead	49	45	4	41.0	38.1	2.9	0.8	0.8	0.7
LQR	Quarry	1	0	1	3.2	0.0	3.2	3.2	0.0	3.2
	Sub Totals	*84*	*76*	*8*	*162.2*	*138.4*	*23.7*	*1.9*	*1.8*	*3.0*
	All Non-vegetation Map Classes Totals	***136***	***104***	***32***	***488.9***	***405.3***	***83.7***	***3.6***	***3.9***	***2.6***
GRAND TOTALS		**2,844**	**2,536**	**308**	**4,972.2**	**4,421.8**	**550.3**	**1.7**	**1.7**	**1.8**

We mapped 2,844 polygons covering 4,972 ha (12,286 acres) with an average polygon size of 1.7 ha (4.3 acres). The Yellow River Unit and environs consists of 2,536 of these polygons (89%) covering 4,422 h (10,926 acres; 89%) of the total map coverage area. The Sny Magill Unit and environs consists of 308 polygons covering 550 ha (1,360 acres). Of the total area mapped, 2,179 polygons (77%) represent NVCS natural/semi-natural plant communities (associations) as defined by NatureServe (2004). These plant communities cover 3,167 ha (7,825 acres; 64%) of the total map area. Map classes representing NVCS Formation level types account for another 529 polygons (18%) of the total polygons and covers 1,316 ha (3,251 acres; 26%) of the total map area. Non-vegetation map classes representing open water and land use types account for the last 136 polygons (52 open water and 84 land use polygons). Open water map classes cover 327 ha (807 acres; 7%) of total map area, by far the majority being the Yellow and Mississippi Rivers. Land use map classes cover 162 ha (401 acres; 3%) of the total map area.

The North-central Maple - Basswood Forest map class, with it's six map class phases, is by far the most common with 1073 polygons covering 1,753 ha (4,331 acres), more than twice as much forest than the Midwestern White Oak - Red Oak Forest map class with it's five map class phases. The frequency of the North-central Maple - Basswood Forest disturbed map class phases (disturbed oak, disturbed maple - basswood, and disturbed hardwoods) far exceeds the other less disturbed map class phases (east-facing maple, north-facing maple, and north-facing red oak). These three disturbed phases combined produced 872 polygons of the primary map class's total 1073 polygons (81% of polygons), encompassing 1,410 ha (3,484 acres) of the 1,753 ha (4,331 acres) of the primary map class coverage (80% of area).

Some map classes are small in size, averaging 0.1 ha (0.25 acres), and validates our decision to map certain types with a smaller MMU of 0.1 ha (0.25 acres). The two Chinquapin Oak Bluff Woodland map class phases and the Goat Prairie Remnant map class are two examples. Without a reduction in MMU, most or all of these vegetation types would not be reflected in the map coverage.

Aside from the River and Stream map class, the map class with the largest average area is the Central Mesic Tallgrass Prairie with slightly over 8 ha (20 acres), however, they are mapped in low frequency with three polygons. These grasslands are the old fields located in the North and South Units that EFMO has converted to tallgrass prairie and managed via fire prescription. A close equal is the Crop Field map class, again slightly over 8 ha (20 acres). Representing an NVCS planted/cultivated Formation type, the Crop Field map class was mapped with 74 polygons covering 604 ha (1,492 acres), accounting for the extensive farming practices surrounding EFMO. The Crop Field map class is closely tied to the Perennial Grass Crop map class, which represents farming practices of hay and pastureland.

EFMO lands (1,022 ha; 2,526 acres) are almost 21% of the entire map coverage. The summary table in Table 11 does not reflect the vegetation landscape of EFMO lands alone. The vegetation landscape from historic and current land management exterior of EFMO assumedly has affected the vegetation composition within this area report. With extracting the EFMO lands from these map coverages, preferably using an accurate park boundary, one can process more in-depth analysis of EFMO's vegetation. For example, one could contrast the health of forest within the park to forest outside the park. And, perhaps one could even compare forests within EFMO boundaries, such as with the newly acquired Heritage Unit and the older North and South Units. Or, possibly one could compare the forest health and historic land management between Iowa state forest and EFMO lands, possibly shedding light on vegetation response to various management practices.

Map Coverage Presentation

Figure 33 presents the map coverage produced from EFMO vegetation mapping project. The finest level of map (the map attribute codes consisting of map classes and physiognomic modifiers) are too detailed to present, therefore the map in Figure 33 is generalized to show NVCS plant communities organized by ES units.

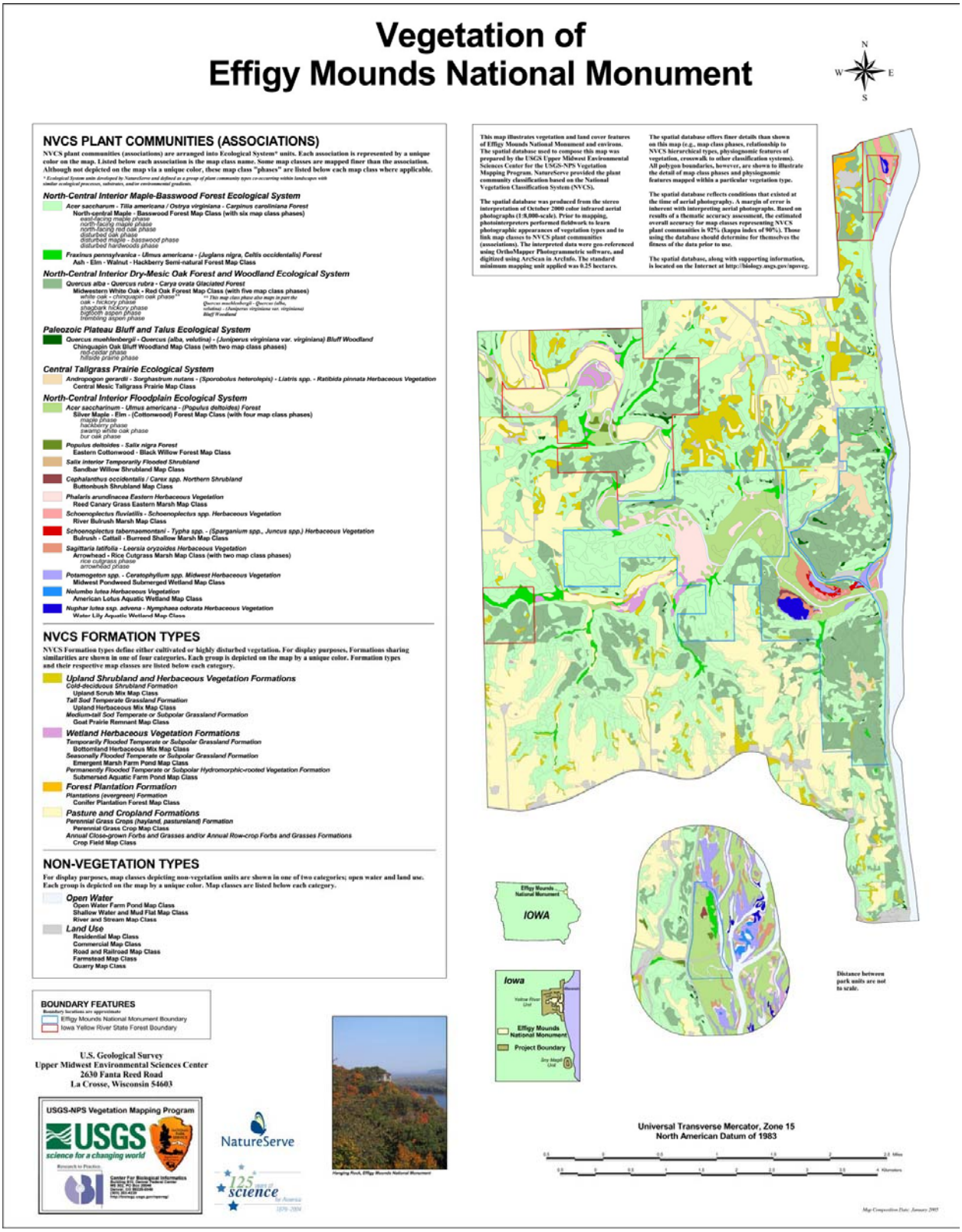


Figure 33. Map composition of Effigy Mounds National Monument and environs.

Accuracy Assessment

Methods

Purpose

The objective of an accuracy assessment is to measure the probability that a particular location has been assigned its correct vegetation class. An accuracy assessment estimates thematic errors in the data, giving users information needed to determine data suitability for a particular application. At the same time, data producers are able to learn more about the nature of errors in the data. Thus, the two views of an accuracy assessment are "producers' accuracy," which is the probability that an accuracy assessment point has been mapped correctly (also referred to as an error of omission), and "users accuracy," which is the probability that the map actually represents what was found on the ground (also referred to as errors of commission). Both users' and producers' accuracy can be obtained from the same set of data using different analyses. Errors occur when map classes are not the same as the classes observed in the field. A major assumption of accuracy assessment is that the process of mapping and the process of the assessment (i.e., the application of the classification system) are identical so a "false error" is not detected because of procedural differences. The challenge here is that the process of accuracy assessment is based on field observance and the process of mapping is based on aerial photointerpretation.

Sampling Design

We used a stratified random sampling approach to acquire accuracy assessment sites. We included all primary map classes along with their phases representing NVCS plant communities (associations) as the individual themes to randomly select sites. Although the map class phases collapse into the primary map class for the final assessment, we wanted the option to validate the phase level of mapping if time permitted. (Recall, a map class phase is a version of a plant community recognizable on the aerial photographs and important to distinguish as a map unit for either management or ecological interests.) We also included some of the natural/semi-natural NVCS Formation and open water map classes in the stratified sampling design so we could judge mapping omission errors of plant communities[1] (e.g., sparser submergent pondweed types missed to an open water map class, disturbed forest phase of forest type missed to Formation shrubland map class). Private lands outside the park were off limits for the evaluation. We did, however, include state lands along the Yellow River and Federal refuge lands adjacent to the Sny Magill Unit. Maximum and minimum sampling sizes for each map class were selected using the VMP recommendations for a medium sized park (TNC et al. 1994) as suggested in the following scenarios:

Scenario A: The class is abundant. It covers more than 50 hectares of the total area and consists of at least 30 polygons. The recommended sample size is 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. 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.

Scenario C: The class is relatively rare. It covers less than 50 hectares of the total area but consists of more than 30 polygons. 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.

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. The recommended number of samples is five. 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 five sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting five sample sites will allow an accuracy estimate to be computed, although it will not be very precise.

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 five sample sites (assuming one 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).

The recommendations above take into account both the statistical and operational aspects of sampling. The accuracy estimate associated with rare classes cannot be stated with the same level of confidence as with more abundant classes. For example, with a sample size of 5, the level of error in the estimate is closer to 25% at a 90% confidence level, as opposed to 10% with a sample size of 27. This has implications for our ability to accept a given point estimate as meeting accuracy requirements. Whether or not a given accuracy estimate is accepted as meeting requirements depends on the width of the confidence interval associated with the point estimate and the outcome of a hypothesis test that determines if a given point estimate is equivalent to or exceeds requirements.

We used the above guidelines in selecting the appropriate number of sites for each map class at EFMO and surrounding state and Federal lands and added extra points to account for inaccessible or remote sites that could potentially be difficult or impractical to reach once in the field. A buffer zone of approximately 10 m from polygon edges was also generated to help reduce problems of error created by using GPS units too near boundaries.

Personnel from UMESC performed the accuracy assessment fieldwork for several reasons. First, a key to the vegetation classes had yet to be developed. Without a working key, a team unfamiliar with the project would be unable to determine the vegetation classes correctly. Second, UMESC personnel had a good working knowledge of the map classes based on experience with the project. We believed that this knowledge would prove the most reliable in making the correct calls, especially between very similar appearing forest stands. Finally, we would likely reduce false errors by applying the same decision rules to determine the classes in the field as were used in the photointerpretation.

We equipped the field team with several tools to maximize their ability to accurately locate each point. We plotted 1:8,000-scale orthophoto quadrangle hard-copy maps (from USGS 3.75-minute digital orthophoto quadrangle images) showing locations of the accuracy assessment sites, the unlabelled polygon boundaries of the vegetation map, and the park and state forest boundaries. Points were uploaded into both PLGR and Garmin III+ GPS receivers (UTM projection, Zone 15, using NAD83).

Field Data Collection

We used both GPS units to navigate to the sites. The Garmin unit brought us into the general location of a site, and the PLGR unit improved our field coordinate precision. We also used hard-copy orthophoto maps with the accuracy assessment site overlaid and USGS topographic maps to help us navigate around environmental barriers. Once the sample site was reached, we evaluated the site an area equal to MMU size and determined the appropriate map class. We also recorded the field GPS coordinate location, dominant species, environmental data, and pertinent comments. For a sample data sheet, refer to Appendix H: Example of an Accuracy Assessment Form. If the area was not homogeneous (containing more than one map class), the other appropriate map classes were also listed on the data sheet.

Our original goal was to collect 507 sites for the accuracy assessment. Our field efforts, however, were slowed considerably from not being able to obtain or keep GPS signals for site navigation. Narrow, deep ravines prevented direct access to the sky and the satellites. In addition, rainy and wet days affected the accuracy and strength of the signals, making navigation difficult or impossible under the forest canopies.

Thus, our total number of sites acquired for the season was 369, about 25% less than originally intended. However, because of our aggressive sampling design of including map class phases with theme stratification, the frequency of sites visited per primary map class themes — that is, once we collapsed the map class phases into their respective primary map class — remained adequate for the most part.

Data Analyses

The accuracy assessment data were entered into the PLOTS Database System (TNC 1997) and reviewed for data entry errors. The analyses of the map accuracy using the field data included the following steps:

- Finalizing the relations of map classes to vegetation types
- Initial comparison analysis of the field and map data
- Review of all disagreements and correcting for false errors as necessary
- Final comparison analysis of the field and map data
- Final output of results into a contingency matrix
- Final output of the analyses and results into a spatial database for use in GIS

Finalizing the relations of map classes to vegetation types: Accuracy assessments within the VMP typically identifies the NVCS plant community of the site. The field assessment data are then compared to the map polygon data to determine the map accuracy. Because we did not yet have a key to the plant communities, we collected map class data during field assessment instead of plant community data. Thus, we needed to develop a link between the two classifications to allow us to use the plant communities as our comparison to the mapped polygons This was straightforward for those map classes and plant communities (associations) having a 1:1 ratio to each other. There are five plant communities, however, that are represented by more than one map class (more specifically, by map class phases), especially of the forest communities. We needed to collapse those map class phases to their respective "parent" map class to achieve a 1:1 ratio between plant communities and map classes.

Initial comparison analysis: With the relations between the two classifications in place, we intersected the field assessment point data with the map polygon data. This allowed us to compare each field accuracy assessment call to the corresponding map class code. We used Microsoft Excel 2000 (Microsoft Corporation) to compare and tabulate the field assessments to the map polygons. Our comparison accounted for all alternative map class calls indicated on the field data sheets. Our analysis accepted alternate field calls matching map polygon calls as correct.

Review of disagreements: All mismatches (disagreements) were subsequently reviewed for false errors. A false error is defined as a mismatch between the map polygon and an accuracy assessment call if caused by an error in GPS field coordinates, a missing or misapplied field call, or a field site assessment area smaller than the polygon minimum mapping unit (an inclusion). This review process involved looking at every polygon and its corresponding accuracy assessment site on the photos. Using both the accuracy assessment site and the vegetation map coverages in ArcView GIS, we located the sites on each photo. We also reviewed the field data sheet to gain fuller context of the ground data. From this process, we corrected disagreements deemed false errors resulting in either a match or a true error using the following concepts:

(1) Spatial GPS coordinate error – occurred when the GPS acquired inaccurate field coordinates causing the site to be located inside an adjacent polygon on the map coverage. Through sampling design — selecting sites more than 10 m from polygon edges — we were able to minimize these errors. There are limitations to the design approach, however, especially with narrow corridor shaped polygons. For sites we determined to have spatial GPS field coordinate displacement, we adjusted accordingly for the analysis to reflect the intended polygon's map class.

(2) Questionable field call – a field assessment call might be questioned during the analysis, especially when the perspective from the ground was limited by poor vantage points, such as a steep slope preventing the field worker from walking around the MMU. If the MMU area is diverse, with more than

one map class represented, it was possible to miss the other map class(es) present. We reviewed these situations by checking the aerial photographs for diversity at the site and by reviewing the field data sheets to see whether access to the entire area was limited. We also reviewed the data for the possibility of another map class not having been recorded. Thus, we were able to update our analysis tables to reflect any additions or changes to the field call in preparation for the second comparison analysis. (We also updated the project's PLOTS Database.)

(3) Inclusion – The area assessed in the field during the accuracy assessment might fall below the MMU for mapping (termed an inclusion). We discovered a few instances where, after reviewing the aerial photographs, the site was an inclusion to the surrounding map class. Certain vegetative features can be quite apparent from each other on the aerial photographs (e.g. open woodland vs. dense forest), allowing easy assessment in the lab of site inclusions.

Final comparison: Of the 369 accuracy assessment sites originally collected, we dropped 34 sites representing the NVCS Formation level types or open water to evaluate exclusively those map classes representing NVCS plant communities. We used the remaining 335 sites for the final comparison analysis. See Figure 34 for locations of accuracy assessment sites used for the analyses.

Contingency table: The results of the final analyses were transferred into a contingency table (matrix) where we calculated user and producer accuracy percentages for each map class. The matrix shows both the frequency of agreement and placement of disagreements.

Accuracy assessment spatial database: For use in GIS, we produced a spatial database of the accuracy assessment site locations, including our analyses and results in the database table. The field data and analyses were also included on the project's PLOTS Database.

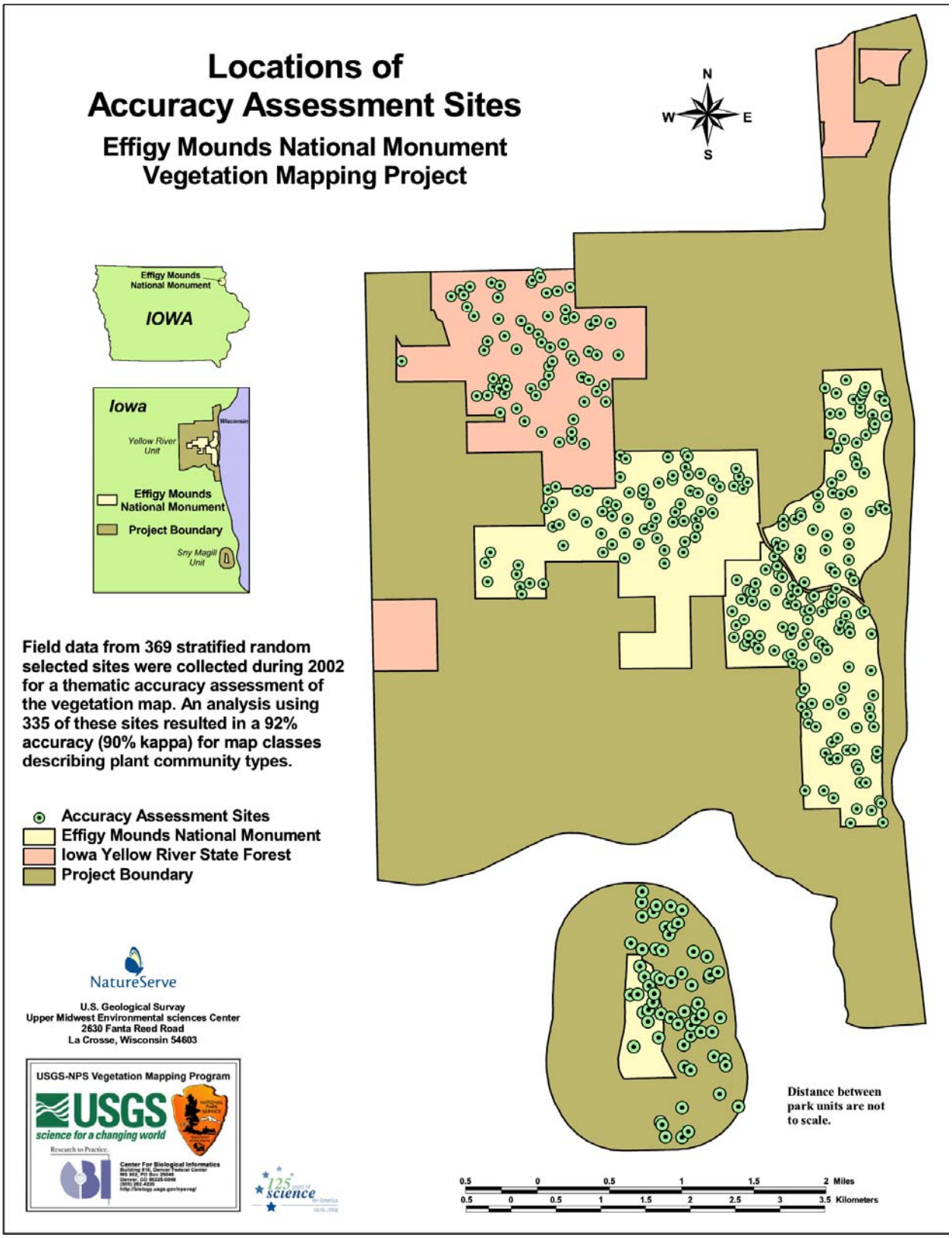


Figure 34. Locations of accuracy assessment sites.

Results and Discussion

Overall accuracy is 92% for primary map classes representing NVCS plant communities (associations). A kappa adjustment for chance agreements equates a final overall accuracy of 90%. The accuracy assessment contingency matrix is in Appendix I: Accuracy Assessment Contingency Table. The matrix shows each map class's accuracy along with 90% confidence intervals, with the users' accuracy reflecting errors of inclusion (commission errors) and producers' accuracy reflecting errors of exclusion (omission errors) present in the mapping. The width of each confidence interval is affected by the sample size used to derive the point estimate.

Our overall accuracy assessment is well above the 80% requirement for the VMP. Individual accuracies also meet the 80% requirement (taking in account the 90% confidence intervals) with few exceptions. The following are map classes not meeting the required accuracy, either with the actual percentage or within the confidence intervals:

(1) Eastern Cottonwood - Black Willow Forest: Producers' accuracy for this class is 20% with a 90% confidence interval of -19–59%. Of the five accuracy assessment sites classified as this community, only one is actually mapped as such. The other four sites are mapped as Silver Maple - Elm - (Cottonwood) Forest (maple phase). This type is often expressed as disturbed narrow corridors along riverbanks, and was difficult for the mapper to distinguish from a silver maple community. Users' accuracy is 50% with a 90% confidence interval of -33–133%. We determined one of the two polygons mapped as the cottonwood type to be the silver maple community on the ground.

(2) American Lotus Aquatic Wetland: Producers' accuracy for this class is 45% with a 90% confidence interval of 16–75%. Of the 11 accuracy assessment sites classified as this community, six are mapped as the Midwest Pondweed Submerged Wetland. We believe these mapping errors were probably caused by different water level conditions during the accuracy assessment year and when the photos were taken. Users' accuracy for this map class is 100% with a 90% confidence interval of 90–110%.

To reiterate, a major assumption of accuracy assessment is that the process of mapping and the process of field assessment (e.g., the process of applying the classification system) are identical, so a false error is not detected because of procedural differences. We were able to reduce the number of false errors because our accuracy assessment used the same decision rules as used during the photointerpretation, with the obvious exception that the assessment was done on site and the photointerpretation was done in the office. This approach, linking the map classes to the vegetation communities after the field data was collected, allowed us to finalize the linkages between the two classifications (map and vegetation) before the comparison analyses, saving time during our evaluation. A disadvantage of this approach is that a vegetation key was not tested in the field, so necessary corrections or additions to the key could not be determined.

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Appendix A

Ecological System Units of Effigy Mounds National Monument

Introduction to Ecological System Units

The following is a subset of the Terrestrial Ecological Systems of the United States (NatureServe 2003b, Comer et al. 2003) and covers Ecological System (ES) units recognized at Effigy Mounds National Monument. This classification has been developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications.

For organizational purposes, we have arranged this project's plant communities and their associated map classes into five ES units. We provide the following as brief descriptions to these units. For full documentation, refer to NatureServe (2003b) and Comer et al. (2003).

CES202.696 NORTH-CENTRAL INTERIOR MAPLE-BASSWOOD FOREST

Division 202, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** high
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Non-Diagnostic Classifiers: Forest and Woodland (Treed), Sideslope, Toeslope/Valley Bottom, Mesotrophic Soil, Deep Soil, Loam Soil Texture
Concept Summary: This system is primarily found in the prairie forest border region of Minnesota, Wisconsin and Iowa, but can range north into northern Minnesota and Wisconsin and south to southern Illinois and eastern Kansas. This forest system is distinguished by underlying mesic soils and the predominance of mesic deciduous species forming a moderately dense to dense canopy. Examples of this system occur on valley slopes and bottoms often with northern or eastern aspects. Soils are moderately well-drained, fertile, and moderate to deep loams that have developed from glacial till or loess parent material. *Acer saccharum* typifies this system with *Tilia americana, Quercus rubra*, and *Ostrya virginiana* often occurring as common associates. The dense canopy allows for a rich mixture of shrub and herbaceous species in the understory. Examples of common herbaceous species include *Anemone quinquefolia, Adiantum pedatum, Arisaema triphyllum*, and *Sanicula* spp. Dynamic processes such as wind and fire can impact this system over long return cycles, however, the most immediate threats to remaining examples of this system are grazing and conversion to agriculture.

CES202.046 NORTH-CENTRAL INTERIOR DRY-MESIC OAK FOREST AND WOODLAND

Division 202, Forest and Woodland

Spatial Scale & Pattern: Large Patch **Classification Confidence:** high
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Diagnostic Classifiers: Forest and Woodland (Treed), Udic, F-Patch/Low Intensity, Quercus - Carya
Non-Diagnostic Classifiers: Footslope, Glaciated uplands, Kame moraine, Lakeplain, Moraine, Temperate [Temperate Continental], Mesotrophic Soil, Loam Soil Texture
Concept Summary: This system is found throughout the glaciated regions of the Midwest, typically in gently rolling landscapes. It can occur on uplands within the prairie matrix and near floodplains, or on rolling glacial moraines and among kettle-kame topography. Soils are typically well-drained Mollisols or Alfisols that range from loamy to sandy loam in texture. Historically, this type was quite extensive in Michigan, Indiana, Illinois, Missouri, Iowa, Wisconsin, and Minnesota. Well over 700,000 hectares likely occurred in southern Michigan alone ca. 1800. It is distinct from other forested systems within the region by a dry-mesic edaphic condition that is transitional between dry oak forests and woodlands and mesic hardwood forests, such as maple-basswood forests. Forest cover can range from dense to moderately open canopy, and there is commonly a dense shrub layer. Fire-resistant oak

species, in particular *Quercus macrocarpa, Quercus rubra*, and/or *Quercus alba*, dominate the overstory. *Carya* spp., including *Carya ovata, Carya cordiformis*, and *Carya alba (= Carya tomentosa)* are diagnostic in portions of the range of this system. Depending on range of distribution, and overstory canopy density, the understory may include species such as *Corylus americana, Amelanchier* spp., *Maianthemum stellatum, Caulophyllum thalictroides, Laportea canadensis, Trillium grandiflorum, Aralia nudicaulis*, and *Urtica dioica*. Occasionally, prairie grasses such as *Andropogon gerardii* and *Panicum virgatum* may be present. Fire constitutes the main natural process for this type and likely maintained a more open canopy structure to support oak regeneration. Historic fire frequency was likely highest in the prairie-forest border areas. Fire suppression may account for the more closed oak forest examples of this system with the more mesic understory. It likely has allowed for other associates such as *Acer saccharum, Celtis occidentalis, Liriodendron tulipifera, Ostrya virginiana*, and *Juglans nigra* to become more prevalent, especially in upland areas along floodplains. Extensive conversion for agriculture has fragmented these systems. Continued fire suppression has also resulted in succession to mesic hardwoods, such that in many locations, no oak species are regenerating. Remaining large areas of this system are likely under considerable pressure due to conversion to agriculture, pastureland, and urban development.

CES202.704 PALEOZOIC PLATEAU BLUFF AND TALUS

Division 202, Forest and Woodland

Spatial Scale & Pattern: Small Patch **Classification Confidence:** medium
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Non-Diagnostic Classifiers: Forest and Woodland (Treed), Woody-Herbaceous, Herbaceous, Bluff, Unglaciated
Concept Summary: This system is found in the driftless regions of southeastern Minnesota, southwestern Wisconsin, and northern Iowa and Illinois. This region was not glaciated like the surrounding areas and thus is predominated by rolling hills and bluff outcrops. This system is found primarily on blufftops and dry upper slopes along the Upper Mississippi River, although it can range into bordering regions such as the Baraboo Hills in Wisconsin. This system contains a mosaic of woodlands, savannas, prairies and sparsely vegetated limestone, dolomite, and/or sandstone outcrops, with occasional talus, especially algific talus. Soils range from thin to moderately deep and are moderately to excessively well-drained with a high mineral content. Woodlands consist of primarily a mixture of oak species such as *Quercus macrocarpa, Quercus rubra, Quercus muehlenbergii*, and *Quercus alba*. *Acer saccharum, Betula alleghaniensis*, and conifer species such as *Pinus* spp. and *Tsuga canadensis* may occur on more mesic and protected areas within this system. Prairie openings (also called "goat prairies") contain *Schizachyrium scoparium* and *Bouteloua curtipendula* with scattered *Juniperus virginiana*. Historically, fire was the most important dynamic maintaining these systems, however, fire suppression within the region has allowed more canopy cover and thus very few prairie openings remain. Algific talus harbors a number of unusual Pleistocene relict species, including plants and snails.

CES205.683 CENTRAL TALLGRASS PRAIRIE

Division 205, Herbaceous

Spatial Scale & Pattern: Matrix **Classification Confidence:** high
Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland
Non-Diagnostic Classifiers: Herbaceous, Glaciated plains, Temperate, Glaciated, Deep Soil, Loam Soil Texture
Concept Summary: This system is found primarily in the Central Tallgrass Prairie Ecoregion ranging from eastern Kansas and Nebraska to northwestern Indiana. This system differs in other prairie systems to the north and south by being the most mesic with primarily deep, rich Mollisol soils. This system is dominated by tallgrass species such as *Andropogon gerardii, Sorghastrum nutans*, and *Panicum virgatum*. Several forb species are also associated with this system making it one of the most diverse grassland systems. As many as just under 300 herbaceous plant species could occur in this system across its range. Fire, drought, and grazing are the primary natural dynamics influencing this system and helped prevent woody species from invading. However, conversion to agriculture has been the prime disturbance since post-European settlement. The rich soils and long growing season make this an ideal location for farming row crops, and as a result very few examples of this system remain.

CES202.694 NORTH-CENTRAL INTERIOR FLOODPLAIN

Division 202, Mixed Upland and Wetland

Spatial Scale & Pattern: Linear **Classification Confidence:** high

Required Classifiers: Natural/Semi-natural, Vegetated (>10% vasc.), Upland, Wetland

Non-Diagnostic Classifiers: Forest and Woodland (Treed), Herbaceous, Floodplain, Glaciated, Sand Soil Texture, Clay Soil Texture, Udic

Concept Summary: This system is found along rivers across the glaciated Midwest. It occurs from river's edge across the floodplain or to where it meets a wet meadow system. It can have a variety of soil types found within the floodplain from very well-drained sandy substrates to very dense clays. It is this variety of substrates and flooding that creates the mix of vegetation that includes *Acer saccharinum, Populus deltoides*, willows, especially *Salix nigra* in the wettest areas, and *Fraxinus pennsylvanica, Ulmus americana*, and *Quercus macrocarpa* in more well-drained areas. Within this system are oxbows that may support *Nelumbo lutea* and *Typha latifolia*. Understory species are mixed, but include shrubs, such as *Cornus drummondii* and *Asimina triloba* (in Kansas), sedges and grasses, which sometimes help form savanna vegetation. Flooding is the primary dynamic process, but drought, grazing, and fire have all had historical influence on this system. Federal reservoirs have had a serious and negative effect on this system, along with agriculture that has converted much of this system to drained agricultural land.

Appendix B

Example of a Plot Sampling Form

USGS - NPS VEGETATION MAPPING PROGRAM – PLOT SURVEY FORM

IDENTIFIERS/LOCATORS

Plot Code EFMO.23

Provisional Community Name silver maple / American elm / Laportea forest

State IA Park Name EFMO Park Site Name Sny Magill N section

Quad Name Clayton Quad Code

Field UTM 4 7 5 5 6 6 8 N'ing Field UTM 6 4 9 4 5 1 E'ing GPS Error ±8.0m

Survey Date 7/24/01 Surveyors S. Lubinski, C. Calogero, M. May – A. Davies

Directions to Plot From visitors center: Turn left & drive south on 76 to the Sny Magill Unit - 11 miles. Turn left at the boat launch sign - gravel road. Park in the parking lot and walk Northwest 2-300 meters to opposite corner. (Middle of silver maple mature stand.)

Plot length 30m Plot width 30m Plot Photos (y/n) ~~23~~ Y Diskette # 23 Frame No. 1-4

Plot Permanent (y/n) n Aerial photo # 9

Plot representativeness Yes

ENVIRONMENTAL DESCRIPTION

Elevation 620' Slope level Aspect 0%

Topographic Position Bottomland (Floodplain)

IF Interfluve **HF** Highslope **MS** Midslope **LS** Lower Slope **T** Toeslope **TB** Hillside Terrace/Bench **LL** Low Level Terrace **B** Basin Floor

Landform

Surficial Geology

Hydrologic regime
___Upland
___Permanently Flooded
___Semipermanently Flooded
✓ Seasonally/Temporarily Flooded
___Unknown

Soil Taxon/Description 149D Canaeek silt loam, channeled, 0-2% slopes.

Soil Texture
___ sand ___ sandy loam ___ loam ___ silt loam A ___
A clay loam ___ clay ___ peat ___ muck B silty clay loam

Soil Drainage
___Rapidly drained ___Well drained ✓ Moderately well drained
___Somewhat poorly drained ___Poorly drained ___Very poorly drained

OM = ½"

Plot Code EFMO, 23

VEGETATION DESCRIPTION

Leaf Type	Physiognomic class	Leaf phenology (of uppermost stratum having >10% cover)
✓ Broad-leaved woody	✓ Forest	Trees and Shrubs: ___ Evergreen; ✓ Deciduous; ✓ Cold-deciduous; ___ Drought-deciduous; ___ Mixed; ___ Mixed evergreen - cold-deciduous; ___ Mixed evergreen - drought-deciduous
___ Needle-leaved woody	___ Woodland	Herbs: ___ Annual; ___ Perennial
___ Graminoid	___ Sparse Woodland	
___ Forb	___ Shrubland	
___ Pteridophyte	___ Sparse Shrubland	
___ Non-vascular	___ Herbaceous	
	___ Sparse vegetation	

Cowardin System
___ Upland ✓ Palustrine ___ Estuarine
___ Lacustrine ✓ Riverine

HISTORY (describe evidence or lack thereof. Indicate how recent if possible)
Fire ___
Wind ___
Cutting ___
Agriculture ___
Livestock Grazing ___
Animal Browsing ___
Other flooding

	Stratum	Height (m)	% Cover	Cover scale	Diagnostic species
T1	EMERGENT				Ace sac, Ulm ame
T2	CANOPY	26m	75%	04	Ace sac, Ulm ame
T3	SUBCANOPY/SAPLING	8m	01%	01	Cel occ.
S1	TALL SHRUB (2m-5m)	—	—	—	—
S2	SHORT SHRUB (<2m)	—	—	—	—
H	HERBACEOUS	0.5m	60%	04	Lap can, Ace sac
N	NON-VASCULAR	—	—	—	—
V	VINE/LIANA	—	—	—	—

Total % cover (T2 + T3): 75% Subcanopy Density: 6

Species outside plot

Comments: Lap can ≈ .5m tall, just growing after prolonged flooding (thru June)
Very large silver maple, even-aged stand. Hundreds of recently germinated silver maple seedlings, about 2-4" tall.

Cover scale for strata: **01** =01 10%, **02** = 10-25%, **03** = 25-60%, **04** = 60-100%

Plot code EFMO. 23

Species/percent cover: starting with the lowermost stratum, list all species and % cover for each in the stratum. For forest and woodlands, list on a separate line below each tree species the DBH of all trees above 10 cm diameter. Separate measurements with a comma. Put an asterisk next to any species that are known diagnostics for a particular community in the classification.

Lap can	05		
Ace saci	02		
Lemna spp	01		
Rhus typ	01.		
Pha arv	01		
		T3 Cel occ IIII	01
		Ulm ame II	01

Cover scale for Species Percent Cover: **01**= 0-<1%, **02**=1-<5%, **03**=5-<25%, **04**=25-<50%, **05**=50-<75%, **06**=75-100%

Plot code EFMO.23

Species/percent cover: starting with the lowermost stratum, list all species and % cover for each in the stratum. For forest and woodlands, list on a separate line below each tree species the DBH of all trees above 10 cm diameter. Separate measurements with a comma. Put an asterisk next to any species that are known diagnostics for a particular community in the classification.

Acer saccharinum			81
57, 66, 50, 47, 80, 50, 51.5,	90, 41, 74.5, 45, 50, 75, 29.5, 43, 57		05
Ulmus americana			
18.5, 11.5, 25, 25, 14, 46,			03
snags (Acer saccharinum)			
20			

Cover scale for Species Percent Cover: **01**= 0-<1%, **02**=1-<5%, **03**=5-<25%, **04**=25-<50%, **05**=50-<75%, **06**=75-100%

First Evangelical Ch
Cem
Norwegian Ch
Cem
Moody Run
Sny Magill Creek
Quarry
Johnsons Slough
UPPER MISSISSIPPI RIVER WILDLIFE AND FISH REF
ISLAND 176
Island 178
Wyalusing
EFFIGY MOUNDS NATIONAL MONUMENT
CHICAGO MILWAUKEE ST PAUL
MISSISSIPPI
NORMAL POOL ELEVATION 611
IOWA
WISCONSIN
Light
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Appendix E

Plant Species List of Effigy Mounds National Monument

We identified and documented more than 400 plant species from the 67 vegetation samples and the 369 accuracy assessment sites we collected for the Effigy Mounds National Monument (EFMO) Vegetation Mapping Project. We entered plant species, along with other sample data, into the PLOTS Database System (TNC 1997) for subsequent analyses (plant community descriptions and map assessment). Table E-1 is an export of all plant species we generated from the project's PLOTS Database. This list is not intended to be comprehensive of every species at EFMO. The plant species list is organized alphabetically within plant families and then by scientific names. Nomenclature follows the PLANTS database (U.S. Department of Agriculture 1996).

Table E-1. Plant species list of Effigy Mounds National Monument.

Family	Scientific Name	Common Name
Aceraceae	*Acer negundo* L.	boxelder
	Acer pensylvanicum L.	striped maple
	Acer rubrum L.	red maple
	Acer saccharinum L.	silver maple
	Acer saccharum Marsh.	sugar maple
Alismaceae	*Alisma subcordatum* Raf.	American water plantain
Alismataceae	*Sagittaria latifolia* Willd.	broadleaf arrowhead
Amaranthaceae	*Amaranthus retroflexus* L.	redroot amaranth
Anacardiaceae	*Rhus glabra* L.	smooth sumac
	Rhus hirta (L.) Sudworth	staghorn sumac
	Toxicodendron pubescens P. Mill.	Atlantic poison oak
	Toxicodendron radicans (L.) Kuntze	eastern poison ivy
	Toxicodendron radicans ssp. *radicans* (L.) Kuntze	eastern poison ivy
Apiaceae	*Angelica atropurpurea* L.	purplestem angelica
	Cryptotaenia canadensis (L.) DC.	Canadian honewort
	Daucus carota L.	Queen Anne's lace
	Eryngium yuccifolium Michx.	button eryngo
	Heracleum maximum Bartr.	common cowparsnip
	Osmorhiza claytonii (Michx.) C.B. Clarke	Clayton's sweetroot
	Osmorhiza longistylis (Torr.) DC.	longstyle sweetroot
	Pastinaca sativa L.	wild parsnip
	Sanicula canadensis L.	Canadian blacksnakeroot
	Sanicula marilandica L.	Maryland sanicle
	Sanicula odorata (Raf.) K.M. Pryer & L.R. Phillippe	clustered blacksnakeroot
	Sanicula trifoliata Bickn.	largefruit blacksnakeroot
	Taenidia integerrima (L.) Drude	yellow pimpernel
	Zizia aptera (Gray) Fern.	meadow zizia
	Zizia aurea (L.) W.D.J. Koch	golden zizia
Apocynaceae	*Apocynum cannabinum* L.	Indianhemp
Araceae	*Arisaema dracontium* (L.) Schott	greendragon

Family	Scientific Name	Common Name
	Arisaema triphyllum (L.) Schott	Jack in the pulpit
	Arisaema triphyllum ssp. *triphyllum* (L.) Schott	Jack in the pulpit
Araliaceae	*Aralia nudicaulis* L.	wild sarsaparilla
	Aralia racemosa L.	wild sarsaparilla
	Panax quinquefolius L.	American ginseng
Aristolochiaceae	*Asarum canadense* L.	Canadian wildginger
Asclepiadaceae	*Asclepias exaltata* L.	poke milkweed
	Asclepias incarnata L.	swamp milkweed
	Asclepias syriaca L.	common milkweed
	Asclepias tuberosa L.	butterfly milkweed
	Asclepias verticillata L.	whorled milkweed
Asteraceae	*Achillea millefolium* L.	common yarrow
	Achillea millefolium var. *puberula* (Rydb.) Nobs	common yarrow
	Ageratina altissima var. *altissima* (L.) King & H.E. Robins.	white snakeroot
	Ambrosia artemisiifolia L.	annual ragweed
	Ambrosia trifida L.	giant ragweed
	Antennaria plantaginifolia (L.) Richards.	woman's tobacco
	Aster cordifolius L.	common blue wood aster
	Aster cordifolius var. *sagittifolius* (Wedemeyer ex Willd.) A.G. Jones	swordleaf wood aster
	Aster drummondii Lindl.	Drummond's aster
	Aster ericoides L.	heath aster
	Aster L.	aster
	Aster lanceolatus ssp. *lanceolatus* var. *lanceolatus* Willd.	white panicle aster
	Aster lateriflorus (L.) Britt.	calico aster
	Aster oolentangiensis var. *oolentangiensis* Riddell	skyblue aster
	Aster pilosus Willd.	white oldfield aster
	Aster prenanthoides Muhl. ex Willd.	crookedstem aster
	Aster sericeus Vent.	western silver aster
	Aster shortii Lindl.	Short's aster
	Aster simplex Willd.	marsh aster
	Bidens cernua L.	nodding beggartick
	Bidens L.	beggartick
	Brickellia eupatorioides var. *eupatorioides* (L.) Shinners	false boneset
	Cirsium altissimum (L.) Hill	tall thistle
	Cirsium arvense (L.) Scop.	Canadian thistle
	Cirsium P. Mill.	thistle
	Cirsium vulgare (Savi) Ten.	bull thistle
	Coreopsis palmata Nutt.	stiff tickseed
	Echinacea pallida (Nutt.) Nutt.	pale purple coneflower
	Echinacea purpurea (L.) Moench	eastern purple coneflower
	Echinacea purpurea (L.) Moench	purple coneflower
	Erigeron strigosus Muhl. ex Willd.	prairie fleabane
	Eupatorium purpureum L.	sweetscented joepyeweed
	Helenium autumnale L.	common sneezeweed
	Helianthus divaricatus L.	woodland sunflower
	Helianthus grosseserratus Martens	sawtooth sunflower
	Helianthus strumosus L.	paleleaf woodland sunflower

Family	Scientific Name	Common Name
	Helianthus X *laetiflorus* Pers. (pro sp.)	mountain sunflower
	Heliopsis helianthoides (L.) Sweet	sunflower heliopsis
	Lactuca biennis (Moench) Fern.	tall blue lettuce
	Lactuca canadensis L.	Canada lettuce
	Lactuca L.	lettuce
	Lactuca serriola L.	prickly lettuce
	Liatris aspera Michx.	tall gayfeather
	Liatris pycnostachya Michx.	cattail gayfeather
	Oligoneuron rigidum var. *rigidum* (L.) Small	
	Polymnia canadensis L.	whiteflower leafcup
	Prenanthes serpentaria Pursh	cankerweed
	Ratibida pinnata (Vent.) Barnh.	pinnate prairie coneflower
	Rudbeckia hirta L.	blackeyed Susan
	Rudbeckia laciniata L.	cutleaf coneflower
	Rudbeckia subtomentosa Pursh	sweet coneflower
	Rudbeckia triloba L.	browneyed Susan
	Silphium perfoliatum L.	cup plant
	Solidago canadensis L.	Canada goldenrod
	Solidago canadensis var. *scabra* Torr. & Gray	Canada goldenrod
	Solidago flexicaulis L.	zigzag goldenrod
	Solidago gigantea Ait.	giant goldenrod
	Solidago L.	goldenrod
	Solidago missouriensis Nutt.	Missouri goldenrod
	Solidago nemoralis Ait.	Dyersweed goldenrod
	Solidago speciosa Nutt.	showy goldenrod
	Solidago ulmifolia Muhl. ex Willd.	elmleaf goldenrod
	Taraxacum officinale G.H. Weber ex Wiggers	common dandelion
	Xanthium strumarium var. *glabratum* (DC.) Cronq.	rough cockleburr
Azollaceae	*Azolla* Lam.	azolla
Balsaminaceae	*Impatiens capensis* Meerb.	jewelweed
	Impatiens pallida Nutt.	pale touchmenot
Berberidaceae	*Berberis thunbergii* DC.	barberry
	Caulophyllum thalictroides (L.) Michx.	blue cohosh
	Podophyllum peltatum L.	mayapple
Betulaceae	*Betula nigra* L.	river birch
	Betula papyrifera Marsh.	paper birch
	Carpinus caroliniana Walt.	American hornbeam
	Corylus americana Walt.	American hazelnut
	Corylus cornuta Marsh.	beaked hazelnut
	Ostrya virginiana (P. Mill.) K. Koch	eastern hophornbeam
Boraginaceae	*Hackelia virginiana* (L.) I.M. Johnston	beggarslice
Brassicaceae	*Alliaria petiolata* (Bieb.) Cavara & Grande	garlic mustard
	Berteroa incana (L.) DC.	hoary false madwort
	Brassica L.	mustard
Bryaceae	*Brachymenium erectum* (Hook.) Marg.	erect brachymenium moss
Campanulaceae	*Campanula americana* L.	tall bellflower
	Campanula rotundifolia L.	bluebell bellflower
	Campanulastrum americanum (L.) Small	American bellflower

Family	Scientific Name	Common Name
	Lobelia cardinalis L.	cardinalflower
	Lobelia inflata L.	Indian tobacco
	Lobelia siphilitica L.	great blue lobelia
Cannabaceae	*Cannabis sativa* L.	marijuana
Caprifoliaceae	*Lonicera dioica* L.	limber honeysuckle
	Lonicera L.	honeysuckle
	Lonicera reticulata Raf.	grape honeysuckle
	Lonicera tatarica L.	Tatarian honeysuckle
	Sambucus L.	elderberry
	Sambucus nigra ssp. *canadensis* (L.) R. Bolli	
	Silphium perfoliatum L.	cup plant
	Triosteum aurantiacum Bickn.	orangefruit horsegentian
	Triosteum L.	horsegentian
	Triosteum perfoliatum L.	feverwort
	Viburnum dentatum L.	southern arrowwood
	Viburnum opulus L.	European cranberrybush viburnum
	Viburnum rafinesquianum J.A. Schultes	downy arrowwood
Caryophyllaceae	*Cerastium arvense* L.	field chickweed
Celastraceae	*Celastrus scandens* L.	American bittersweet
	Euonymus atropurpurea Jacq.	eastern wahoo
Ceratophyllaceae	*Ceratophyllum demersum* L.	coon's tail
Chenopodiaceae	*Chenopodium album* L.	lambsquarters
Clusiaceae	*Hypericum ascyron* L.	great St. Johnswort
	Hypericum L.	St. Johnswort
	Hypericum punctatum Lam.	spotted St. Johnswort
Commelinaceae	*Tradescantia ohiensis* Raf.	bluejacket
Convolvulaceae	*Calystegia sepium* ssp. *sepium* (L.) R. Br.	hedge false bindweed
	Convolvulus scammonia L.	scammony
Cornaceae	*Cornus alternifolia* L. f.	alternateleaf dogwood
	Cornus amomum P. Mill.	silky dogwood
	Cornus racemosa Lam.	gray dogwood
Cucurbitaceae	*Echinocystis lobata* (Michx.) Torr. & Gray	wild cucumber
	Sicyos angulatus L.	oneseed burr cucumber
Cupressaceae	*Juniperus communis* L.	common juniper
	Juniperus virginiana L.	eastern redcedar
Cyperaceae	*Bolboschoenus fluviatilis* (Torr.) Soj k	river bulrush
	Carex albursina Sheldon	white bear sedge
	Carex blanda Dewey	eastern woodland sedge
	Carex convoluta Mackenzie	rosy sedge
	Carex eburnea Boott	bristleleaf sedge
	Carex eburnea Rydb.	bristleleaf sedge
	Carex grayi Carey	Gray's sedge
	Carex L.	sedge
	Carex lacustris Willd.	hairy sedge
	Carex lupulina Muhl. ex Willd.	hop sedge
	Carex mesochorea Mackenzie	midland sedge
	Carex pensylvanica Lam.	Pennsylvania sedge

Family	Scientific Name	Common Name
	Carex plantaginea Lam.	plantainleaf sedge
	Carex rosea Schkuhr ex Willd.	rosy sedge
	Carex stipata Muhl. ex Willd.	owlfruit sedge
	Eleocharis cancellata S. Wats.	Arizona spikerush
	Eleocharis quinqueflora (F.X. Hartmann) Schwarz	fewflower spikerush
	Schoenoplectus tabernaemontani (K.C. Gmel.) Palla	
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn	western brackenfern
Dioscoreaceae	*Dioscorea villosa* L.	wild yam
Dryopteridaceae	*Athyrium filix-femina* (L.) Roth	common ladyfern
	Cystopteris bulbifera (L.) Bernh.	bulblet bladderfern
	Cystopteris fragilis (L.) Bernh.	brittle bladderfern
	Dryopteris intermedia (Muhl. ex Willd.) Gray	intermediate woodfern
	Onoclea sensibilis L.	sensitive fern
Equisetaceae	*Equisetum fluviatile* L.	water horsetail
Euphorbiaceae	*Euphorbia corollata* L.	flowering spurge
Fabaceae	*Amorpha brachycarpa* Palmer	leadplant
	Amorpha canescens Pursh	leadplant
	Amphicarpaea bracteata (L.) Fern.	American hogpeanut
	Apios americana Medik.	groundnut
	Baptisia alba var. *macrophylla* (Larisey) Isely	largeleaf wild indigo
	Baptisia leucantha Torr. & Gray	wild indigo
	Chamaecrista fasciculata (Michx.) Greene	sleepingplant
	Dalea purpurea var. *purpurea* Vent.	violet prairieclover
	Desmodium canadense (L.) DC.	showy ticktrefoil
	Desmodium Desv.	ticktrefoil
	Desmodium glutinosum (Muhl. ex Willd.) Wood	pointedleaf ticktrefoil
	Desmodium nudiflorum (L.) DC.	nakedflower ticktrefoil
	Gleditsia triacanthos L.	honeylocust
	Gymnocladus dioicus (L.) K. Koch	Kentucky coffeetree
	Lespedeza capitata Michx.	roundhead lespedeza
	Lupinus perennis L.	sundial lupine
	Melilotus alba Medikus	white sweetclover
	Robinia pseudoacacia L.	black locust
	Trifolium arvense L.	rabbitfoot clover
	Trifolium L.	clover
	Trifolium pratense L.	red clover
Fagaceae	*Quercus alba* L.	white oak
	Quercus bicolor Willd.	swamp white oak
	Quercus coccinea Muenchh.	scarlet oak
	Quercus macrocarpa Michx.	bur oak
	Quercus macrocarpa-alba	
	*Quercus muehlenbergi*i Engelm.	chinkapin oak
	Quercus muhlenbergii-alba	
	Quercus rubra L.	northern red oak
Gentianaceae	*Gentiana alba* Muhl. ex Nutt.	plain gentian
	Gentiana puberulenta J. Pringle	downy gentian
Geraniaceae	*Geranium maculatum* L.	spotted geranium
Grossulariaceae	*Ribes americanum* P. Mill.	American black currant

Family	Scientific Name	Common Name
	Ribes cynosbati L.	eastern prickly gooseberry
	Ribes L.	currant
	Ribes missouriense Nutt.	Missouri gooseberry
Haloragaceae	*Myriophyllum* L.	watermilfoil
	Myriophyllum spicatum L.	spike watermilfoil
Hamamelidaceae	*Hamamelis virginiana* L.	American witchhazel
Hydrocharitaceae	*Elodea canadensis* Michx.	Canadian waterweed
	Vallisneria americana Michx.	American eelgrass
Hydrophyllaceae	*Hydrophyllum appendiculatum* Michx.	great waterleaf
	Hydrophyllum canadense L.	bluntleaf waterleaf
	Hydrophyllum virginianum L.	Shawnee salad
Iridaceae	*Iris versicolor* L.	harlequin blueflag
Juglandaceae	*Carya cordiformis* (Wangenh.) K. Koch	bitternut hickory
	Carya ovata (P. Mill.) K. Koch	shagbark hickory
	Juglans cinerea L.	butternut
	Juglans nigra L.	black walnut
Juncaceae	*Juncus tenuis* Willd.	poverty rush
Lamiaceae	*Blephilia hirsuta* (Pursh) Benth.	hairy pagodaplant
	Glechoma hederacea L.	groundivy
	Leonurus cardiaca L.	common motherwort
	Lycopus uniflorus Michx.	northern bugleweed
	Mentha arvensis L.	wild mint
	Monarda fistulosa L.	wildbergamot beebalm
	Physostegia leptophylla Small	slenderleaf false dragonhead
	Physostegia virginiana (L.) Benth.	
	Physostegia virginiana ssp. *virginiana* (L.) Benth.	obedient plant
	Pycnanthemum virginianum (L.) T. Dur. & B.D. Jackson ex B.L. Robins. & Fern.	Virginia mountainmint
	Scutellaria elliptica var. *elliptica* Muhl. ex Spreng.	hairy skullcap
	Scutellaria L.	skullcap
	Scutellaria lateriflora L.	blue skullcap
	Scutellaria parvula Michx.	small skullcap
	Stachys palustris L.	marsh hedgenettle
	Teucrium canadense L.	Canada germander
	Teucrium canadense L.	Candad germander
Lemnaceae	*Lemna* L.	duckweed
	Lemna minor L.	common duckweed
	Lemna trisulca L.	star duckweed
Liliaceae	*Allium tricoccum* Ait.	wild leek
	Maianthemum racemosum ssp. *racemosum* (L.) Link	feather Solomon's seal
	Polygonatum biflorum (Walt.) Ell.	king Solomon's seal
	Trillium grandiflorum (Michx.) Salisb.	snow trillium
	Trillium L.	trillium
	Uvularia grandiflora Sm.	largeflower bellwort
Menispermaceae	*Menispermum canadense* L.	common moonseed
Moraceae	*Morus* L.	mulberry
	Morus rubra L.	red mulberry
Nelumbonaceae	*Nelumbo lutea* Willd.	American lotus

Family	Scientific Name	Common Name
Nymphaeaceae	*Nymphaea odorata* Ait.	American white waterlily
Oleaceae	*Fraxinus americana* L.	white ash
	Fraxinus L.	ash
	Fraxinus nigra Marsh.	black ash
	Fraxinus pennsylvanica Marsh.	green ash
Onagraceae	*Circaea lutetiana* ssp. *canadensis* (L.) Aschers. & Magnus	broadleaf enchanter's nightshade
	Oenothera biennis L.	common eveningprimrose
	Oenothera L.	eveningprimrose
Ophioglossaceae	*Botrychium virginianum* (L.) Sw.	rattlesnake fern
Orchidaceae	*Galearis spectabilis* (L.) Raf.	showy orchid
	Goodyera pubescens (Willd.) R. Br. ex Ait. f.	downy rattlesnake plantain
Oxalidaceae	*Oxalis montana* Raf.	mountain woodsorrel
	Oxalis stricta L.	common yellow oxalis
Papaveraceae	*Sanguinaria canadensis* L.	bloodroot
Pinaceae	*Pinus strobus* L.	eastern white pine
Plantaginaceae	*Plantago rugelii* Dcne.	blackseed plantain
Poaceae	*Agrostis gigantea* Roth	redtop
	Agrostis vinealis ssp. *vinealis* Schreb.	brown bentgrass
	Andropogon gerardii Vitman	big bluestem
	Bouteloua curtipendula (Michx.) Torr.	sideoats grama
	Brachyelytrum erectum (Schreb. ex Spreng.) Beauv.	bearded shorthusk
	Bromus carinatus Hook. & Arn.	California brome
	Bromus ciliatus L.	fringed brome
	Bromus inermis Leyss.	smooth brome
	Bromus L.	brome
	Danthonia spicata (L.) Beauv. ex Roemer & J.A. Schultes	poverty danthonia
	Dichanthelium acuminatum var. *fasciculatum* (Torr.) Freckmann	western panicgrass
	Dichanthelium latifolium (L.) Gould & C.A. Clark	broadleaf rosette grass
	Dichanthelium oligosanthes var. *oligosanthes* (J.A. Schultes) Gould	Heller's rosette grass
	Elymus canadensis L.	Canada wildrye
	Elymus hystrix var. hystrix L.	eastern bottlebrush grass
	Elymus L.	wildrye
	Elymus villosus Muhl. ex Willd.	hairy wildrye
	Elymus virginicus L.	Virginia wildrye
	Elytrigia intermedia (Host) Nevski	intermediate wheatgrass
	Elytrigia repens var. *repens* (L.) Desv. ex B.D. Jackson	quackgrass
	Koeleria macrantha (Ledeb.) J.A. Schultes	prairie Junegrass
	Leersia oryzoides (L.) Sw.	rice cutgrass
	Leersia Sw.	cutgrass
	Lolium pratense (Huds.) S.J. Darbyshire	
	Muhlenbergia cuspidata (Torr. ex Hook.) Rydb.	plains muhly
	Muhlenbergia mexicana (L.) Trin.	Mexican muhly
	Muhlenbergia Schreb.	muhly
	Muhlenbergia tenuiflora (Willd.) B.S.P.	slender muhly
	Panicum L.	panicum
	Panicum oligosanthes J.A. SchultesDichanthelium *oligosanthes* var. *oligosanthes* (J.A. Schultes) Gould	Heller's rosette grass

Family	Scientific Name	Common Name
	Phalaris arundinacea L.	reed canarygrass
	Piptatherum racemosum Ricker ex A.S. Hitchc.	
	Poa L.	bluegrass
	Poa pratensis L.	Kentucky bluegrass
	Schizachyrium scoparium (Michx.) Nash	little bluestem
	Setaria Beauv.	bristlegrass
	Sorghastrum nutans (L.) Nash	yellow Indiangrass
Polemoniaceae	*Phlox pilosa* L.	downy phlox
	Polemonium reptans L.	Greek valerian
Polygalaceae	*Polygala sanguinea* L.	purple milkwort
Polygonaceae	*Polygonum amphibium* var. *emersum* Michx.	longroot smartweed
	Polygonum L.	knotweed
	Polygonum scandens L.	climbing false buckwheat
	Polygonum virginianum L.	jumpseed
	Rumex crispus L.	curly dock
	Rumex L.	dock
	Rumex salicifolius var. *lacustris* (Greene) Hickman	lake willow dock
Pontederiaceae	*Heteranthera dubia* (Jacq.) MacM.	grassleaf mudplantain
Potamogetonaceae	*Potamogeton crispus* L.	curly pondweed
	Potamogeton foliosus Raf.	leafy pondweed
	Potamogeton nodosus Poir.	longleaf pondweed
Primulaceae	*Dodecatheon amethystinum* (Fassett) Fassett	jeweled shootingstar
	Dodecatheon meadia L.	pride of Ohio
	Lysimachia ciliata L.	fringed loosestrife
	Lysimachia nummularia L.	creeping jenny
Pteridaceae	*Adiantum pedatum* L.	northern maidenhair
Ranunculaceae	*Actaea* L.	baneberry
	Actaea pachypoda Ell.	white baneberry
	Actaea rubra (Ait.) Willd.	red baneberry
	Anemone canadensis L.	Canadian anemone
	Anemone cylindrica Gray	candle anemone
	Anemone L.	anemone
	Anemone quinquefolia L.	nightcaps
	Anemone virginiana L.	tall thimbleweed
	Aquilegia canadensis L.	red columbine
	Hepatica nobilis var. *acuta* (Pursh) Steyermark	sharplobe hepatica
	Hepatica P. Mill.	hepatica
	Hydrastis canadensis L.	goldenseal
	Hydrastis L.	hydrastis
	Pulsatilla vulgaris Miller	European pasqueflower
	Ranunculus abortivus L.	littleleaf buttercup
	Thalictrum dasycarpum Fisch. & Ave-Lall.	purple meadowrue
	Thalictrum dioicum L.	early meadowrue
	Thalictrum thalictroides (L.) Eames & Boivin	rue anemone
Rhamnaceae	*Rhamnus cathartica* L.	common buckthorn
	Rhamnus L.	buckthorn
Rosaceae	*Agrimonia gryposepala* Wallr.	tall hairy agrimony
	Crataegus L.	hawthorn

Family	Scientific Name	Common Name
	Fragaria virginiana Duchesne	Virginia strawberry
	Geum canadense Jacq.	white avens
	Geum triflorum Pursh	prairiesmoke
	Physocarpus opulifolius (L.) Maxim.	common ninebark
	Potentilla simplex Michx.	common cinquefoil
	Prunus americana Marsh.	American plum
	Prunus serotina Ehrh.	black cherry
	Prunus virginiana L.	common chokecherry
	Pyrus L.	pear
	Rosa L.	rose
	Rosa multiflora Thunb. ex Murr.	multiflora rose
	Rubus allegheniensis Porter	Allegheny blackberry
	Rubus idaeus L.	American red raspberry
	Rubus L.	blackberry
	Rubus occidentalis L.	black raspberry
Rubiaceae	*Cephalanthus occidentalis* L.	common buttonbush
	Galium boreale L.	northern bedstraw
	Galium circaezans Michx.	licorice bedstraw
	Galium concinnum Torr. & Gray	shining bedstraw
	Galium lanceolatum Torr.	lanceleaf wild licorice
	Galium triflorum Michx.	fragrant bedstraw
Rutaceae	*Ptelea trifoliata* L.	common hoptree
	Zanthoxylum americanum P. Mill.	common pricklyash
Salicaceae	*Populus deltoides* Bartr. ex Marsh.	eastern cottonwood
	Populus grandidentata Michx.	bigtooth aspen
	Populus L.	cottonwood
	Populus tremuloides Michx.	quaking aspen
	Salix exigua Nutt.	sandbar willow
	Salix nigra Marsh.	black willow
Saxifragaceae	*Heuchera richardsonii* R. Br.	Richardson's alumroot
	Mitella diphylla L.	twoleaf miterwort
Scrophulariaceae	*Pedicularis canadensis* L.	Canadian lousewort
	Penstemon grandiflorus Nutt.	large beardtongue
	Veronicastrum virginicum (L.) Farw.	Culver's root
Smilacaceae	*Smilax ecirrata* (Engelm. ex Kunth) S. Wats.	upright carrionflower
	Smilax herbacea L.	smooth carrionflower
	Smilax tamnoides L.	bristly greenbrier
Solanaceae	*Physalis heterophylla* Nees	clammy groundcherry
	Solanum dulcamara L.	climbing nightshade
	Solanum nigrum L.	black nightshade
	Solanum umbelliferum Eschsch.	bluewitch nightshade
Sparganiaceae	*Sparganium eurycarpum* Engelm. ex Gray	broadfruit burreed
	Sparganium L.	burreed
Staphyleaceae	*Staphylea trifolia* L.	American bladdernut
Tiliaceae	*Tilia americana* L.	American basswood
Typhaceae	*Typha latifolia* L.	broadleaf cattail
Ulmaceae	*Celtis occidentalis* L.	common hackberry
	Ulmus americana L.	American elm

Family	Scientific Name	Common Name
	Ulmus pumila L.	Siberian elm
	Ulmus rubra Muhl.	slippery elm
Urticaceae	*Boehmeria cylindrica* (L.) Sw.	smallspike false nettle
	Boehmeria Jacq.	false nettle
	Laportea canadensis (L.) Weddell	Canadian woodnettle
	Pilea pumila (L.) Gray	Canadian clearweed
	Urtica dioica L.	stinging nettle
	Urtica dioica ssp. *gracilis* (Ait.) Seland.	California nettle
Verbenaceae	*Phryma leptostachya* L.	American lopseed
	Stachytarpheta X *trimeni* Rech.	porterweed
	Verbena L.	verbena
	Verbena stricta Vent.	hoary verbena
	Verbena urticifolia L.	white vervain
Violaceae	*Viola* L.	violet
	Viola pubescens Ait.	downy yellow violet
Vitaceae	*Parthenocissus quinquefolia* (L.) Planch.	Virginia creeper
	Vitis aestivalis Michx.	summer grape
	Vitis riparia Michx.	riverbank grape

Appendix F

Example of an Observation Field Reconnaissance Form

UMESC PHOTO INTERPRETATION FIELD DATA FORMS
EFFIGY MOUNDS NATIONAL MONUMENT

IDENTIFIERS/LOCATORS

Site # 25 Date 10-3-01 Other field Personnel Hop, Pruka, Cologno, Lubinski

Garmin 3+

USGS 7.5' Quad R. DuCatten GPS Model GARMIN 3+ GPS Zone 15 GPS Error 1.4

GPS Location (UTM NAD 83) Easting 6 4 7 9 5 8 Northing 4 7 6 9 7 8 7

Description of site relative to topo mark 46

AERIAL PHOTOGRAPHY

Photo # 16 Date 10-9-2000 Type CIR Scale 1:8000

Description of Photo Signature oak canopy - big crowns - rich pink, fairly fluffy

ENVIRONMENTAL DESCRIPTION

Elevation (m) _____ Aspect _____ (1 = flat 2 =N 3=S 4=E/W)

Topographic Position _____ Soil Texture (check one) sand ____ silt ____ clay ____

VEGETATION DESCRIPTION	Strata	Height	% Cover	Diagnostic Species
	T1 Emergent	70'	75-80	red oak
Leaf Type				white oak
___Broad-leaved				
___Needle-leaved	T2 Canopy		75	sugar maple
___Microphyllous				
___Graminoid				
___Forb	T3 Sub-canopy			
___Pteridophyte		2-5		sugar maple
Leaf Phenology (of uppermost stratum having > 10% cover)	S1 Tall Shrub			Afow Ostrya vir
___Evergreen	S2 Short Shrub			
___Deciduous				
___Mixed				sparse understory
Herbs	H Herbaceous			Amphbrac
___Annual				Adi ped
__Perennial	N Non-vascular			Inter fern
	V Vine			

GROUND PHOTO

Roll # C Exposure # F82 Direction N Roll # _____ Exposure # _____ Direction ____

F83 E

Appendix G

Map Classification Descriptions and Visual Guide

Introduction to Map Class Descriptions & Guide

This appendix provides descriptions of the 47 map classes we used to map Effigy Mounds National Monument (EFMO) for the USGS-NPS Vegetation Mapping Program. We have organized map classes representing plant communities (associations) of the National Vegetation Classification System (NVCS) into Ecological System (ES) units (NatureServe 2003b, Comer et al 2003). We organized map classes representing NVCS Formation level types (FGDC 1997) and non-vegetated features (open water and land use) into nonstandard, project-specific categories.

Each map class description provides the formal map class name and the map class code we developed and used for mapping. Names for map classes representing NVCS plant communities are the same names as the community's synonym names as provided by NatureServe (2003a). Names for map classes representing NVCS Formation level types (e.g., fallow fields, crop fields) or non-vegetated features (e.g., roads, farmsteads) are project specific and do not reflect a standardized name. However, they do echo in concept either NVCS Formation level types or USGS land use and land cover (LULC) classification units (Anderson et al. 1976).

For visual reference, we provide at least one representative ground photo for each map class, including map class phases (see main section of report for further explanation on map class phases). We also describe each map class from a mapping perspective, and include the relation to the NVCS, or to the LULC classification when the NVCS is not applicable.

We occasionally use map class codes instead of full map class names throughout the descriptions. Map classification codes and names associated to the NVCS classification are in Table G-1 (for NVCS plant communities) and Table G-2 (for NVCS Formation level types). Codes and names associated to LULC classification system are in Table G-3.

The EFMO vegetation map is split into two coverages, a larger coverage of the Yellow River Unit and environs, and a smaller coverage of the Sny Magill Unit and environs about 10 miles further south. Every map class is not present in both coverages. Of the 47 total map classes, the Yellow River coverage has 44 map classes with 17 unique to the coverage. The Sny Magill coverage has 30 map classes with three unique to the coverage. Table G-4 provides a quick reference to the map coverages each map class exists.

All map classes are mapped to 0.25 ha (0.62 acres), unless otherwise noted.

Table G-1. Map classification representing NVCS plant communities (associations).

Map Class Code	Map Class Name	NVCS Association Scientific Name (NatureServe)	NVCS Association Synonym Name (NatureServe 2003)	NatureServe CEGL Code	NVCS Code
NVCS PLANT COMMUNITY (ASSOCIATION) CLASSES					
North-Central Interior Maple-Basswood Forest					
-	North-central Maple - Basswood Forest	*Acer saccharum - Tilia americana / Ostrya virginiana - Carpinus caroliniana* Forest	North-central Maple - Basswood Forest	CEGL002062	I.B.2.N.a.8
FOM	*east-facing maple phase*	-	-	-	-
FMB	*north-facing maple phase*	-	-	-	-
FNO	*north-facing red oak phase*	-	-	-	-
FOX	*disturbed oak phase*	-	-	-	-
FOB	*disturbed maple - basswood phase*	-	-	-	-
FMH	*disturbed hardwoods phase*	-	-	-	-
FRH	Ash - Elm - Walnut - Hackberry Semi-natural Forest	*Fraxinus pennsylvanica - Ulmus americana - (Juglans nigra, Celtis occidentalis)* Forest	Ash - Elm - Walnut - Hackberry Semi-natural Forest	CEGL005239	I.B.2.N.a.47
North-Central Interior Dry-Mesic Oak Forest and Woodland					
-	Midwestern White Oak - Red Oak Forest	*Quercus alba - Quercus rubra - Carya ovata* Glaciated Forest	Midwestern White Oak - Red Oak Forest	CEGL002068	I.B.2.N.a.27
FWO	white oak - chinquapin oak phase*	-	-	-	-
FOH	*oak - hickory phase*	-	-	-	-
FSH	*shagbark hickory phase*	-	-	-	-
FBA	*bigtooth aspen phase*	-	-	-	-
FTA	*trembling aspen phase*	-	-	-	-
Paleozoic Plateau Bluff and Talus					
-	Chinquapin Oak Bluff Woodland	*Quercus muehlenbergii - Quercus (alba, velutina) - (Juniperus virginiana* var. *virginiana)* Bluff Woodland	Chinquapin Oak Bluff Woodland	CEGL002144	II.B.2.N.a.21
FRC	*red-cedar phase*	-	-	-	-
FHP	*hillside prairie phase*	-	-	-	-
Central Tallgrass Prairie					
HRP	Central Mesic Tallgrass Prairie	*Andropogon gerardii - Sorghastrum nutans - (Sporobolus heterolepis) - Liatris* spp. - *Ratibida pinnata* Herbaceous Vegetation	Central Mesic Tallgrass Prairie	CEGL002203	V.A.5.N.a.2

Map Class Code	Map Class Name	NVCS Association Scientific Name (NatureServe)	NVCS Association Synonym Name (NatureServe 2003)	NatureServe CEGL Code	NVCS Code
North-Central Interior Floodplain					
-	Silver Maple - Elm - (Cottonwood) Forest	*Acer saccharinum* - *Ulmus americana* - *(Populus deltoides)* Forest	Silver Maple - Elm - (Cottonwood) Forest	CEGL002586	I.B.2.N.d.4
FMC	*maple phase*	-	-	-	-
FEH	*hackberry phase*	-	-	-	-
FSW	*swamp white oak phase*	-	-	-	-
FBO	*bur oak phase*	-	-	-	-
FCW	Eastern Cottonwood - Black Willow Forest	*Populus deltoides* - *Salix nigra* Forest	Midwestern Cottonwood - Black Willow Forest	CEGL002018	I.B.2.N.d.15
SWL	Sandbar Willow Shrubland	*Salix interior* Temporarily Flooded Shrubland	Sandbar Willow Shrubland	CEGL008562	III.B.2.N.d.6
SBB	Northern Buttonbush Swamp	*Cephalanthus occidentalis / Carex* spp. Northern Shrubland	Northern Buttonbush Swamp	CEGL002190	III.B.2.N.f.1
HCG	Reed Canary Grass Eastern Marsh	*Phalaris arundinacea* Eastern Herbaceous Vegetation	Reed Canary Grass Eastern Marsh	CEGL006044	V.A.5.N.k.20
HRB	River Bulrush Marsh	*Schoenoplectus fluviatilis* - *Schoenoplectus* spp. Herbaceous Vegetation	River Bulrush Marsh	CEGL002221	V.A.5.N.k.26
HGB	Bulrush - Cattail - Burreed Shallow Marsh	*Schoenoplectus tabernaemontani* - *Typha* spp. - *(Sparganium* spp., *Juncus spp.)* Herbaceous Vegetation	Bulrush - Cattail - Burreed Shallow Marsh	CEGL002026	V.A.5.N.k.33
-	Arrowhead - Rice Cutgrass Marsh	*Sagittaria latifolia* - *Leersia oryzoides* Herbaceous Vegetation	Arrowhead - Rice Cutgrass Marsh	CEGL005240	V.B.2.N.e.7
HRC	*rice cutgrass phase*	-	-	-	-
HBA	*arrowhead phase*	-	-	-	-
HPW	Midwest Pondweed Submerged Wetland	*Potamogeton* spp. - *Ceratophyllum* spp. Midwest Herbaceous Vegetation	Midwest Pondweed Submerged Aquatic Wetland	CEGL002282	V.C.2.N.a.14
HAL	American Lotus Aquatic Wetland	*Nelumbo lutea* Herbaceous Vegetation	American Lotus Aquatic Wetland	CEGL004323	V.C.2.N.a.100
HWL	Water Lily Aquatic Wetland	*Nuphar lutea* ssp. *advena* - *Nymphaea odorata* Herbaceous Vegetation	Water Lily Aquatic Wetland	CEGL002386	V.C.2.N.a.102

** The white oak - chinquapin oak phase map class phase (FWO) maps in part Chinquapin Oak Bluff Woodland (II.B.2.N.a.21.002144) due to limitations in recognizing this class on the aerial photographs.*

Table G-2. Map classification representing NVCS Formation level types.

Map Class Code	Map Class Name	NVCS Formation Name (FGDC 1997)	NVCS Code
NVCS FORMATION TYPE CLASSES			
Upland Shrubland and Herbaceous Vegetation			
SUS	Upland Scrub Mix	Cold-deciduous shrubland	III.B.2.N.a
HUF	Upland Herbaceous Mix	Tall sod temperate grassland	V.A.5.N.a
HGP	Goat Prairie Remnant	Medium-tall sod temperate or subpolar grassland	V.A.5.N.c
Wetland Herbaceous Vegetation			
HBF	Bottomland Herbaceous Mix	Temporarily flooded temperate or subpolar grassland	V.A.5.N.j
HEP	Emergent Marsh Farm Pond	Seasonally flooded temperate or subpolar grassland	V.A.5.N.k
HSP	Submersed Aquatic Farm Pond	Permanently flooded temperate or subpolar hydromorphic-rooted vegetation	V.C.2.N.a
Forest Plantation			
FCP	Conifer Plantation Forest	Plantations (evergreen)*	I.A.8.C.a
Pasture and Cropland			
HPG	Perennial Grass Crop	Perennial grass crops (hayland, pastureland)	V.A.5.C.a
HCF	Crop Field	Annual close-grown forbs and grasses and/or Annual row-crop forbs and grasses	V.D.2.C.a V.D.2.C.b

** Standard FGDC name is Plantations (planted timber stands, Christmas trees). We modified name to indicate plantations are of evergreen trees.*

Table G-3. Map classification representing USGS LULC level II types.

Map Class Code	Map Class Name	USGS Land Use and Land Cover Name (Anderson et al. 1976)	LULC Code Level 2
NON-VEGETATION CLASSES			
Open Water			
OFP	Open Water Farm Pond	Other Agricultural land	24
OSM	Shallow Water and Mud Flat	Streams and Canals	51
ORS	River and Stream	Streams and Canals	51
Land Use			
LRS	Residential	Residential	11
LCM	Commercial	Commercial and Services	12
LRR	Road and Railroad	Transportation, Communications, and Utilities	14
LFB	Farmstead	Other Agricultural land	24
LQR	Quarry	Strip Mines, Quarries, and Gravel Pits	75

Table G-4. Map classification assignments to the Yellow River and Sny Magill map coverages.

Map Code	Map Class Name	YLW	SNY
NVCS PLANT COMMUNITY (ASSOCIATION) CLASSES			
North-Central Interior Maple-Basswood Forest			
-	North-central Maple - Basswood Forest	-	-
FOM	*east-facing maple phase*	x	x
FMB	*north-facing maple phase*	x	x
FNO	*north-facing red oak phase*	x	
FOX	*disturbed oak phase*	x	x
FOB	*disturbed maple - basswood phase*	x	x
FMH	*disturbed hardwoods phase*	x	x
FRH	Ash - Elm - Walnut - Hackberry Semi-natural Forest	x	x
North-Central Interior Dry-Mesic Oak Forest and Woodland			
-	Midwestern White Oak - Red Oak Forest	-	-
FWO	*white oak - chinquapin oak phase*	x	x
FOH	*oak - hickory phase*	x	x
FSH	*shagbark hickory phase*	x	x
FBA	*bigtooth aspen phase*	x	x
FTA	*trembling aspen phase*	x	
Paleozoic Plateau Bluff and Talus			
-	Chinquapin Oak Bluff Woodland	-	-
FRC	*red-cedar phase*	x	
FHP	*hillside prairie phase*	x	x
Central Tallgrass Prairie			
HRP	Central Mesic Tallgrass Prairie	x	
North-Central Interior Floodplain			
-	Silver Maple - Elm - (Cottonwood) Forest	-	-
FMC	*maple phase*	x	x
FEH	*hackberry phase*	x	x
FSW	*swamp white oak phase*	x	
FBO	*bur oak phase*		x
FCW	Eastern Cottonwood - Black Willow Forest	x	x
SWL	Sandbar Willow Shrubland	x	
SBB	Northern Buttonbush Swamp	x	x
HCG	Reed Canary Grass Eastern Marsh	x	x
HRB	River Bulrush Marsh	x	
HGB	Bulrush - Cattail - Burreed Shallow Marsh	x	
-	Arrowhead - Rice Cutgrass Marsh	-	-
HRC	*rice cutgrass phase*	x	x
HBA	*arrowhead phase*	x	
HPW	Midwest Pondweed Submerged Wetland	x	x
HAL	American Lotus Aquatic Wetland		x
HWL	Water Lily Aquatic Wetland	x	x

Map Code	Map Class Name	YLW	SNY
NVCS FORMATION TYPE CLASSES			
Upland Shrubland and Herbaceous Vegetation			
SUS	Upland Scrub Mix	x	
HUF	Upland Herbaceous Mix	x	x
HGP	Goat Prairie Remnant	x	
Wetland Herbaceous Vegetation			
HBF	Bottomland Herbaceous Mix	x	x
HEP	Emergent Marsh Farm Pond	x	
HSP	Submersed Aquatic Farm Pond	x	
Forest Plantation			
FCP	Conifer Plantation Forest	x	
Pasture and Cropland			
HPG	Perennial Grass Crop	x	x
HCF	Crop Field	x	x
NON-VEGETATION CLASSES			
Open Water			
OFP	Open Water Farm Pond	x	
OSM	Shallow Water and Mud Flat	x	x
ORS	River and Stream	x	x
Land Use			
LRS	Residential	x	
LCM	Commercial	x	
LRR	Road and Railroad	x	x
LFB	Farmstead	x	x
LQR	Quarry		x

Descriptions of Map Classes Representing NVCS Plant Communities (Associations)

We developed 30 map classes representing 16[1] NVCS natural/semi-natural plant communities (associations) we describe with this project, making an almost 2:1 ratio of map class units to plant community types. This ratio is a result of mapping versions (phases) of five plant communities. We developed map class phases when a version of a plant community was recognizable on the aerial photographs and had importance for either management or ecological interests. As a result, 19 map classes each represent a phases to 1 of 5 plant communities. The other 11 map classes each represent a single plant community. For the most part, the phase classes of forest types reflect disturbance history. We used canopy crown size, relative dominance of individual tree species, and patchiness of canopies as criteria to distinguish forested-type map class phases from one another. From this information, map users can begin to distinguish between older and younger stands, and gain a sense of the degree of disturbance[1]. For the two map class phases describing the Arrowhead - Rice Cutgrass Marsh community, we used dominance of emergent species to determine the appropriate map class phase.

We have included these phase units in these map class descriptions. The name assigned to each map class is the synonym name of the NVCS plant community (association) it represents (synonym name as provided by NatureServe 2003a). (Note the phase unit portion of the name is not part of the plant community synonym name.)

We have organized these 30 map classes into 5 ES units (NatureServe 2003b), based on the NVCS plant communities they represent. They are as follows:

- North-Central Interior Maple-Basswood Forest,
- North-Central Interior Dry-Mesic Oak Forest and Woodland,
- Paleozoic Plateau Bluff and Talus,
- Central Tallgrass Prairie,
- North-Central Interior Floodplain.

The ES unit each map class is assigned is listed at the bottom of each map class description page. The five ES units are described in Appendix A: Ecological System Units of Effigy Mounds National Monument.

Furthermore, Appendix C: Plant Community Descriptions of Effigy Mounds National Monument and Appendix D: Dichotomous Key to Plant Communities of Effigy Mounds National Monument can be used to compliment these map classes descriptions representing NVCS plant communities.

North-central Maple - Basswood Forest (FOM, FMB, FNO, FOX, FOB, and FMH)

The North-central Maple - Basswood Forest map class represents the North-central Maple - Basswood Forest plant community (CEGL002062). This community is the most common upland forest at EFMO. Stands exist on ridge tops and all slope aspects. Although maple and basswood define the name of this community, oaks, especially red oak, is often a prominent component of the canopy. As little as 10% relative dominance of either sugar maple or basswood in the canopy can define this community. We used this map class to map forests where sugar maple is >25% relative dominance, as low as 10% when meeting specific criteria (e.g., recent forest disturbance).

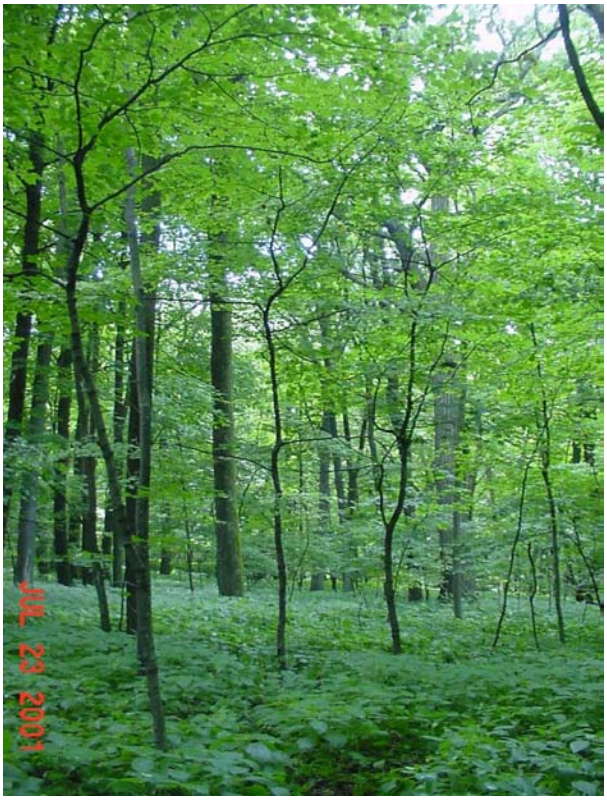
The North-central Maple - Basswood Forest map class is split into six map class phases, three depicting what we consider to be relatively high-quality forests, or forests that appear to have minimal human disturbance in recent 50 years or so (east-facing maple, north-facing maple, and north-facing red oak phases) and three depicting more significant and obvious human disturbance in recent years (disturbed oak, disturbed maple - basswood, and disturbed hardwoods phases).

North-central Maple - Basswood Forest (east-facing maple phase) – FOM

The east-facing maple (FOM) map class phase represents the maple - basswood forest type of steep (typically above 65% slope) bluffs of the Mississippi River, of eastern-facing slopes, aspects ranging from northeast to southeast. These forests contain many of the largest diameter trees at EFMO and-appear to have been least influenced by historic logging activities over the last century, perhaps due to the steepness of the slopes. Dominant trees are sugar maple, American basswood, and red oak. Some white oak is also present. Sugar maple is >25% relative dominance and can have significant amounts of oak present (e.g. >25% relative dominance). Closely associated to this maple - basswood map class phase is the oak-hickory phase (FOH) of the Midwestern White Oak - Red Oak Forest map class (representing the Midwestern White Oak - Red Oak Forest plant community). When FOH is used along these same steep, east-facing bluffs, red oak is dominant with <25% relative dominance of sugar maple.

North-central Maple - Basswood Forest (north-facing maple phase) – FMB

The north-facing maple (FMB) map class phase represents the maple - basswood forest type of ravines and northern-facing slopes, aspects ranging from northeast to northwest. When not in ravines, these are most common at base of north-aspect slopes. Stands of FMB exist on the richest and most mesic of soils in shaded environments, and are where the most significant populations of spring ephemerals are likely to be found. These forests are the most fire and drought protected within EFMO. Dominant trees are sugar maple and American basswood, with red oak usually present, but in low density of <25% relative dominance. Closely associated to this phase is the north-facing red oak phase (FNO) of the same parent map class, where red oak is >25% relative dominance and usually further up these north-aspect slopes where the soils are slightly dryer.



North-central Maple - Basswood Forest (north-facing red oak phase) – FNO

The north-facing red oak (FNO) map class phase represents the maple - basswood forest type of northern-facing slopes, aspects ranging from northeast to northwest, often found higher up the slope above the north-facing maple phase (FMB) where soils are slightly dryer. Dominant trees are red oak, sugar maple, and American basswood, with red oak >25% relative dominance. The FMB map class phase is closely associated to the FNO phase, where red oak is <25% relative dominance and usually toward the base of these north-facing slopes. Stands of FNO represent a transition between FMB and the oak-hickory phase (FOH) of the Midwestern White Oak - Red Oak Forest map class, containing more oak than FMB, and an understory component that contains spring ephemerals as well as species common to the oak - hickory forests. The FNO phase, similar to the FMB phase, is fire and drought protected because of their aspect range and mesic soils.

North-central Maple - Basswood Forest (disturbed oak phase) – FOX

The disturbed oak (FOX) map class phase represents the maple - basswood forest type that has been affected by repeated, selective logging over the past few decades or so. These forests are found on all aspects and slopes, with more exception to very steep bluffs. This map class phase consists of stands that have >25% relative dominance of both red oak and sugar maple. Most, and sometimes all, the trees are relatively young comprised of sugar maple, American basswood, red oak, shagbark hickory, and white ash. Sugar maple comprises >25% relative dominance, unlike its two other disturbed map class phase counterparts (FOB and FMH below) where sugar maple can be as low as 10%.

In contrast, the oak-hickory phase (FOH) of the Midwestern White Oak - Red Oak Forest map class represents red oak trees of later succession with larger crown diameters, and sugar maple is <25% relative dominance. Forest canopy openings of FOX suggest recent forest disturbance, and the physiognomic modifiers we added to the classification of polygons reflect these disturbance patterns.

Both the FOX and the disturbed maple - basswood phase (FOB below) are common in the Heritage Unit and on private lands where forest stands are often grazed and adjoin herbaceous pasturelands (e.g., HPG map class). In the Heritage Unit, we observed during our fieldwork many species common to open woodlands and savannas in small cleared areas where ample light was available, especially in stands on interfluves. It seems that logging efforts have inadvertently provided a refuge for species probably more common in the past.

North-central Maple - Basswood Forest (disturbed maple - basswood phase) – FOB

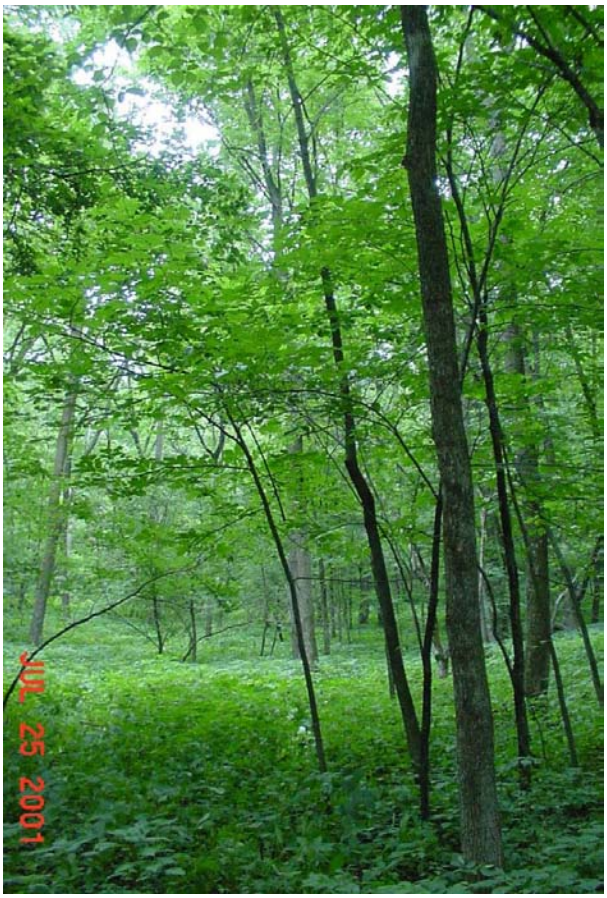
The disturbed maple - basswood (FOB) map class phase represents the maple - basswood forest type that has been logged of oak and is now dominated by sugar maple and/or American basswood. Where basswood dominates, sugar maple may fall as low as 10% relative dominance. Very little red oak remains in FOB stands. The canopy typically has a patchy appearance due to disturbance. We used physiognomic modifiers to reflect the patchy nature. These forests are found on all aspects and slopes, with more exception to very steep slopes along bluffs.

North-central Maple - Basswood Forest (disturbed hardwoods phase) – FMH

The disturbed hardwoods (FMH) map class phase represents the maple - basswood forest type where clear cutting has occurred in the recent past. This phase represents the most disturbed of all the maple - basswood map class phases. No individual tree species dominates these forest stands, and sugar maple can be as low 10% relative dominance. Small diameter tree canopies epitomize this phase, and a patchy appearance of canopy openings is evident, which we captured with physiognomic modifiers. Again, like the FOX and FOB disturbed phases, these forests are found on all aspects and most slopes, except very steep slopes along bluffs.

Ash - Elm - Walnut - Hackberry Semi-natural Forest (FRH)

The Ash - Elm - Walnut - Hackberry Semi-natural Forest (FRH) map class represents the Ash - Elm - Walnut - Hackberry Semi-natural Forest plant community (CEGL005239). Stands exist on mesic, disturbed upland ravines and higher floodplain terraces. Most stands of FRH have been grazed. Common tree species are black ash, American elm, American walnut, and northern hackberry. FRH transitions into the North-central Maple - Basswood Forest up the slope or in dryer portions of ravines, and transitions into the Silver Maple - Elm - (Cottonwood) Forest map class, chiefly the maple (FMC) and hackberry (FEH) phases, toward the bottomlands.



Midwestern White Oak - Red Oak Forest (FWO, FOH, FSH, FBA, and FTA)

The Midwestern White Oak - Red Oak Forest map class represents the Midwestern White Oak - Red Oak Forest plant community (CEGL002068). This forest community is widespread throughout EFMO, existing on mid- to high-slopes of all aspects. A closed canopy of red and white oak, and sometimes big-tooth aspen or hickory (where the oak was previously logged) characterizes it. Soils are typically dry-mesic. We used this map class to describe areas where white oak, red oak, shagbark hickory, and/or aspens dominate the forest stands and sugar maple is <25% relative dominance, or as low as 10% when we determined evidence of recent forest disturbance, as explained with the disturbed maple - basswood (FOB) and disturbed hardwoods (FMH) phases of the North-central Maple - Basswood Forest map class.

This map class is split into five map class phases depicting recurring variations within the vegetation type. With five phases, two indicate high-quality forests (white oak - chinquapin oak, oak - hickory phases) and the other three indicate low-quality forests signifying recent disturbance (shagbark hickory, bigtooth aspen, and trembling aspen phases). We mapped the trembling aspen phase to 0.1 ha (0.25 acres) MMU.

Midwestern White Oak - Red Oak Forest (white oak - chinquapin oak phase) – FWO

The white oak - chinquapin oak (FWO) map class phase represents the oak forest type on interfluves. This phase exists on dry to dry-mesic soils and is considered the driest of all phases within the Midwestern White Oak - Red Oak Forest map class. The understory reflects more woodland and savanna species that flourish under open canopies. Canopy cover is typically open (60–85%), with trees consisting mostly of white oak and/or chinquapin oak, with shagbark hickory and red oak present at <25% relative dominance. A small amount of bur oak may also be present. Stands with encroaching ironwood and sugar maple require active management to retain the woodland-like character of this forest phase.

In addition to representing the Midwestern White Oak - Red Oak Forest plant community, this phase also represents, in part, the Chinquapin Oak Bluff Woodland plant community (CEGL002144), which almost always exists in small stands <0.25 ha (1.25 acres). The Chinquapin Oak Bluff Woodland plant community is also mapped within the Chinquapin Oak Bluff Woodland map class where it is split into two phases, red-cedar (FRC) and hillside prairie (FHP), and mapped to 0.1 ha (0.25 acres) MMU. Because of their typical small area, we were limited in our mapping of these woodlands when integrated with the FWO map class phase.

Midwestern White Oak - Red Oak Forest (oak - hickory phase) – FOH

The oak - hickory (FOH) map class phase represents best out of all five of the oak forest's phases a "typical" Midwestern White Oak - Red Oak Forest plant community as described in the NVCS. This phase characterizes a forest of mature red oak, white oak, and shagbark hickory. These are dry to dry-mesic forest stands, with a wide variety of herbaceous species in the understory. Oak trees are tall with crowns large and broad, and sugar maple trees are <25% relative dominance. Both of these distinctions were key to our mapping and classifying this map class phase.

To this map class phase only, we applied an additional physiognomic modifier to define amount of oak dominance. With this modifier, one can distinguish stands of FOH of >75% relative dominance oak trees from those of 25–75%. Making this distinction provides yet another level of information to draw on for those managing and researching these forest stands most typifying the plant community in which they represent.

As noted in the North-central Maple - Basswood Forest map class, both east-facing maple (FOM) and disturbed oak (FOX) phases, the FOH map class phase has similar tree species composition. However, the maple - basswood forests have >25% sugar maple relative dominance.

Midwestern White Oak - Red Oak Forest (shagbark hickory phase) – FSH

The shagbark hickory (FSH) map class phase represents the oak forest type dominated by shagbark hickory because of historic selective logging of oak trees. These hickory dominated stands may include larger diameter red oaks, but <25% relative dominance.

Midwestern White Oak - Red Oak Forest (bigtooth aspen phase) – FBA

The bigtooth aspen (FBA) map class phase represents the oak forest type dominated by bigtooth aspen. These stands were most likely clear-cut in the past. Red oak and other hardwoods may be present, but in low relative dominance.

Midwestern White Oak - Red Oak Forest (trembling aspen phase) – FTA

The trembling aspen (FTA) map class phase represents the oak forest type dominated by trembling aspen, and is usually found along edges of fields and other disturbed areas. Like the bigtooth aspen phase, these stands were most likely clear-cut in the past. Trembling aspen stands are often short in stature and pole like small DBH widths, consistent with early forest succession. Small amounts of bigtooth aspen and other deciduous trees may be present, but in low relative dominance. Because trembling aspen stands are typically small in area, we mapped this phase to 0.1 ha (0.62 acres) MMU.

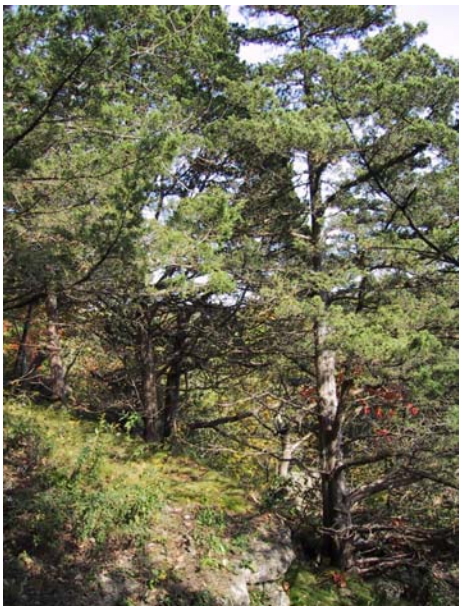
Chinquapin Oak Bluff Woodland (FRC and FHP)

The Chinquapin Oak Bluff Woodland map class represents the Chinquapin Oak Bluff Woodland plant community (CEGL002144). This woodland exists mostly on steep south- to southwest-facing bluffs above the Mississippi and Yellow Rivers. Eastern red-cedar is usually present from low to high relative dominance. We used this map class to map woodlands with varying densities of chinquapin oak and red-cedar.

This map class is split into two map class phases (red-cedar and hillside prairie phases). With these woodlands typically small in area, we mapped each map class phase to 0.1 ha MMU.

Chinquapin Oak Bluff Woodland (red-cedar phase) – FRC

The red-cedar (FRC) map class phase represents the oak woodland type with red-cedar dominant. These are common along bluff tops, vistas, and steep hillsides. Some stands were originally goat prairies, having similar herbaceous composition of a dry prairie. With the high density of red-cedar, this map class phase is indicative of areas protected by fire. The deciduous component is <25% relative dominance.



Chinquapin Oak Bluff Woodland (hillside prairie phase) – FHP

The hillside prairie (FHP) map class phase represents the oak woodland type on southern-aspect slopes. The FHP exists on south- to southwest-facing slopes that were originally open oak woods, but now are more closed. These stands retain some of the original woodland community understory species. The canopy consists of a mix of almost any tree species, but eastern red-cedar and bur oak are often found.

Central Mesic Tallgrass Prairie (HRP)

The Central Mesic Tallgrass Prairie (HRP) map class represents the Central Mesic Tallgrass Prairie plant community (CEGL002203). At EFMO, this community exists on uplands that were previously grazed pasturelands. The park has planted and managed through prescribed burning several hectares of prairie in the North and South Units. These prairies are mesic grasslands consisting of big bluestem, Indiangrass, and a variety of forbs.

Silver Maple - Elm - (Cottonwood) Forest (FMC, FEH, FSW, and FBO)

The Silver Maple - Elm - (Cottonwood) Forest map class represents the Silver Maple - Elm - (Cottonwood) Forest plant community (CEGL002586). Large stands are common, especially along the Mississippi River. These river bottomland forests are typically inundated in spring, but may become relatively drained later in the season. We used this map class to describe bottomland floodplain forests of the Yellow and Mississippi Rivers.

The map class is split into four map class phases (maple, hackberry, swamp white oak, and bur oak phases).

Silver Maple - Elm - (Cottonwood) Forest (maple phase) – FMC

The maple (FMC) map class phase represents the floodplain forest type dominated by silver maple, with lower densities of cottonwood, elm, hackberry, and ash. It is the most commonly present phase within this floodplain forest community.

Silver Maple - Elm - (Cottonwood) Forest (hackberry phase) – FEH

The hackberry (FEH) map class phase represents the floodplain forest type dominated by northern hackberry. Usually quite open, these areas were historically dense forest, most likely codominated by silver maple, until logged and used for cattle grazing. Reed canary grass is the predominant herbaceous layer, and areas <25% hackberry trees are commonly mapped as Reed Canary Grass Eastern Marsh (HCG).

Silver Maple - Elm - (Cottonwood) Forest (swamp white oak phase) – FSW

Rare, the swamp white oak (FSW) map class phase represents the floodplain forest type with large diameter swamp white oak trees. The only existence of mapping size is bordering the west end of Founders Pond.

Although rare within EFMO, FSW is more common in the Mississippi River floodplain, where stands exist in slightly higher and dryer habitats than stands dominated by silver maple. However, we did not recognize any FSW meeting MMU in the Mississippi River floodplain areas included in the map extent of this project.

Silver Maple - Elm - (Cottonwood) Forest (bur oak phase) – FBO

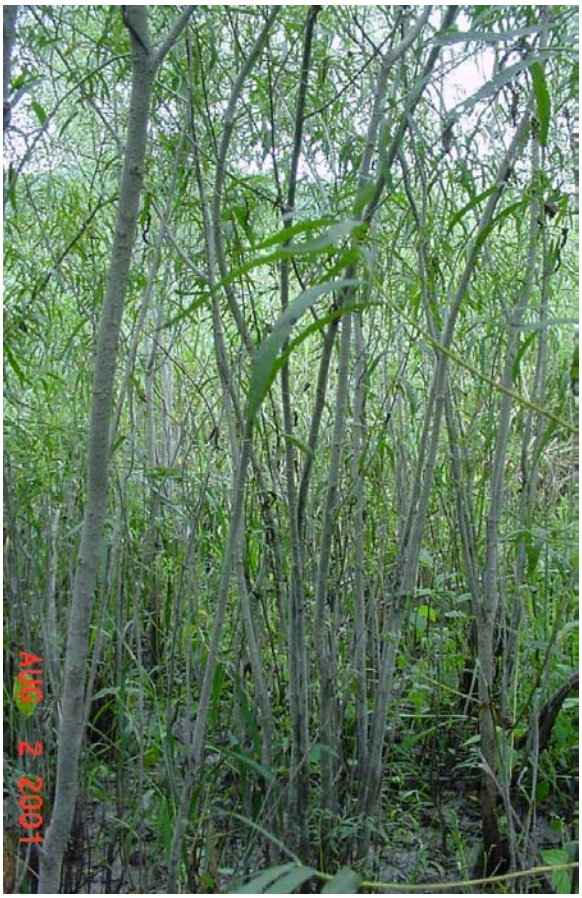
Also rare, the bur oak (FBO) map class phase represents the floodplain forest type with large diameter bur oak trees found on a low terrace in the Mississippi River floodplain within Sny Magill Unit. Other species included silver maple, American elm, green ash, and swamp white oak. Stands of bottomland bur oak are relatively uncommon to rare within this stretch of the Mississippi floodplain.

Eastern Cottonwood - Black Willow Forest (FCW)

The Eastern Cottonwood - Black Willow Forest (FCW) map class represents the Eastern Cottonwood - Black Willow Forest plant community (CEGL002018). This map class depicts cottonwood dominated bottomland forests with silver maple <25% relative dominance. Relatively uncommon within EFMO, FCW exists in both the Yellow River and Mississippi River floodplains as tall, mature stands.

Sandbar Willow Shrubland (SWL)

The Sandbar Willow Shrubland (SWL) map class represents the Sandbar Willow Shrubland plant community (CEGL008562). This type is an early successional stage existing on recently flooded riparian areas. Although rare within EFMO, SWL is relatively common along the Mississippi River, forming dense stands on alluvial sands where flooding is common in the spring.



Northern Buttonbush Swamp (SBB)

The Northern Buttonbush Swamp (SBB) map class represents the Northern Buttonbush Swamp plant community (CEGL002190). This type occupies shallow water depressions and backwater sloughs in the Mississippi and Yellow River floodplains. Buttonbush is usually the only shrub present. A scattered tree canopy of silver maple may be present, and due to flooding, the herbaceous layer may be sparse.

Reed Canary Grass Eastern Marsh (HCG)

The Reed Canary Grass Eastern Marsh (HCG) map class represents the Reed Canary Grass Eastern Marsh plant community (CEGL006044). Nearly monotypic stands, reed canary grass is widespread in the Yellow River bottomlands and islands within the Mississippi River floodplain. Some wet meadow species characteristic of wet meadows may also be present. Dead snags are common in the Yellow River floodplain where historic logging and grazing diminished much of the floodplain forest. Scattered silver maple and northern hackberry are common in the Yellow River, but <25% cover. Areas where maples or hackberry are >25% cover, the maple phase (FMC) or hackberry phase (FEH) of the Silver Maple - Elm - (Cottonwood) Forest map class defines the area. Reed canary grass displaces native species over time, and is difficult to eradicate.

River Bulrush Marsh (HRB)

The River Bulrush Marsh (HRB) map class represents the River Bulrush Marsh plant community (CEGL002221). Although rare within EFMO, river bulrush is common along the Mississippi River, in large, monospecific stands in backwaters. Stands of river bulrush are usually flooded in springtime. We used this map class to map river bulrush stands in shallow water within the Yellow River floodplain near the confluence to the Mississippi River.

Bulrush - Cattail - Burreed Shallow Marsh (HGB)

The Bulrush - Cattail - Burreed Shallow Marsh (HGB) map class represents the Bulrush - Cattail - Burreed Shallow Marsh plant community (CEGL002026). Similar to the River Bulrush Marsh map class (HRB), giant burreed is rare within EFMO and it is common in Mississippi River backwaters. Stands of giant burreed are usually flooded in springtime. At EFMO, the growth is monotypic, dominated with giant burreed. We used this map class to map giant burreed in shallow water in the Yellow River floodplain near the confluence to the Mississippi River.

Arrowhead - Rice Cutgrass Marsh (HRC and HBA)

The Arrowhead - Rice Cutgrass Marsh map class represents the Arrowhead - Rice Cutgrass Marsh plant community (CEGL005240). Stands are found in backwaters of the Mississippi River near the Sny Magill Unit and in the Yellow River bottomlands of the Yellow River Unit in close proximity to the confluence with the Mississippi River. This map class is split into two map class phases (rice cutgrass and arrowhead phases).

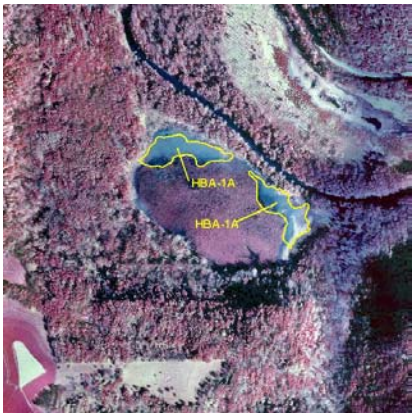
Arrowhead - Rice Cutgrass Marsh (rice cutgrass phase) – HRC

The rice cutgrass (HRC) map class phase represents the wet meadow community dominated by rice cutgrass. It grows in slightly shallower water than the arrowhead phase. Arrowhead typically grows with it, but in low density for this map class phase.

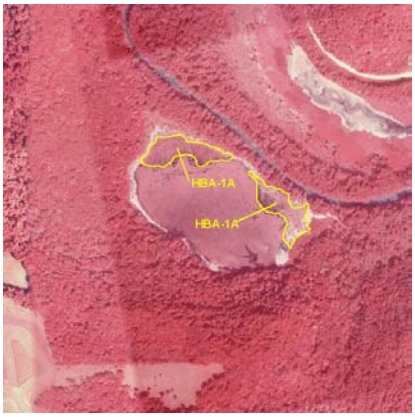
Arrowhead - Rice Cutgrass Marsh (arrowhead phase) – HBA

The arrowhead (HBA) map class phase represents the wet meadow community dominated by broadleaf arrowhead, although narrowleaf arrowhead may be present. It grows in slightly deeper water than the rice cutgrass phase. Normally in the Mississippi River floodplain, an arrowhead dominated stand often grows between a stand of rice cutgrass and deeper aquatic vegetation types (e.g., submergent, hydromorphic). However, we noticed these margins, particularly of the Sny Magill Unit area, were void of arrowhead because of extreme flooding of recent years. The incidence of rice cutgrass is typical, mostly in transition and in low density.

Arrowhead plants were completely senesced during the October-dated photography. So, we used the August-dated photography to identify and locate stands of arrowhead. The only growth of HBA was in Founders Pond of the Yellow River Unit.



HBA on October photography

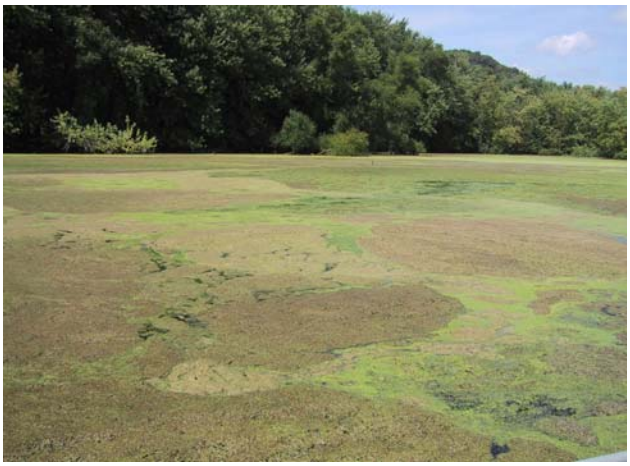


HBA on August photography

Broadleaf Arrowhead

Midwest Pondweed Submersed Wetland (HPW)

The Midwest Pondweed Submersed Wetland (HPW) map class represents the Midwest Pondweed Submersed Wetland plant community (CEGL002282). This is a broadly defined community that has several subgroups (see global plant community description). At EFMO, however, the dominant species includes coontail, water stargrass, and curly-leaved pondweed. These submersed aquatic species often form dense stands in shallow backwaters of the Mississippi River and in Founders Pond. Because of early senescence of submergent plants, we used the August-dated photography to confirm our interpretation of this vegetation on the October-dated photography.



American Lotus Aquatic Wetland (HAL)

The American Lotus Aquatic Wetland (HAL) map class represents the American Lotus Aquatic Wetland plant community (CEGL004323). This community is prevalent throughout the Mississippi River floodplain and grows in shallow backwaters in the vicinity of the Sny Magill Unit area. Patches of submersed aquatic plant species and duckweed may be found among the lotus leaves. Because of early senescence of this aquatic plant, we used the August-dated photography to confirm our interpretation of American lotus on the October-dated photography.

Water Lily Aquatic Wetland (HWL)

The Water Lily Aquatic Wetland (HWL) map class represents the Water Lily Aquatic Wetland plant community (CEGL002386). This community occupies shallow backwaters of the Mississippi River of the Sny Magill Unit area and Founders Pond of the Yellow River Unit. Submersed aquatic plant species and duckweed are often interspersed among the floating leaves. Because of early senescence of this aquatic plant, we use the August-dated photography to confirm our interpretation of water lily on the October-dated photography.

Descriptions of Map Classes Representing NVCS Formation Types

Some vegetation types cannot be assigned to a plant community or an alliance level type due to disturbance (e.g., fallow field, pine plantation, pastureland). Thus, we developed map classes representing the appropriate NVCS Formation unit. We derived nine map classes to represent ten vegetation units at the NVCS Formation level. Six of these map classes represent six natural/semi-natural vegetation units. The other three map classes represent four planted/cultivated vegetation units. The name assigned to each map class is a project derived. We have organized these ten map classes representing Formation level units into four categories. They are as follows:

- Upland Shrubland and Herbaceous Vegetation,
- Wetland Herbaceous Vegetation,
- Forest Plantation,
- Pasture and Cropland.

The category each map class is within is listed at the bottom of each map class description page.

Three of the ten NVCS Formation level units, in the hierarchical sense, also capture seven of the plant community types already described by their own map class. However, to reiterate, we needed to develop these additional map classes at the Formation level to define vegetation not meeting NVCS classification criteria at either the plant association or alliance level.

Upland Scrub Mix (SUS)

The Upland Scrub Mix (SUS) map class represents the NVCS Cold-deciduous Shrubland Formation (III.B.2.N.a). It is a natural/semi-natural vegetation unit. However, we mapped to the Formation level because this vegetation could not be linked to a plant community or alliance type.

This map class is composed of a variety of native and nonnative shrubs that have weedy tendencies. Dominant species include gooseberries, blackberries, and raspberries, multiflora rose, and prickly-ash. Scattered trees are often present. Weedy goldenrods are often present in the herbaceous layer. SUS is found on old fallow fields and on formerly grazed pasturelands.

Upland Herbaceous Mix (HUF)

The Upland Herbaceous Mix (HUF) map class represents the Tall Sod Temperate Grassland Formation (V.A.5.N.a). It is a natural/semi-natural vegetation unit. However, we mapped to the Formation level because this vegetation could not be linked to a plant community or alliance type.

This map class is composed of a variety of native and nonnative forb and grasses, most which have weedy tendencies. Dominant species include Canada goldenrod, Kentucky bluegrass, giant ragweed, and wild parsnip. Scattered trees and weedy shrubs are often present. HUF is found on old fallow fields, formerly grazed pasturelands, and along roadsides.

The Central Mesic Tallgrass Prairie (HRP) map class hierarchically lists under the V.A.5.N.a Formation unit. However, HRP is mapped separately as it represents a plant community of the NVCS.

Goat Prairie Remnant (HGP)

The Goat Prairie Remnant (HGP) map class represents the Medium-tall Sod Temperate or Subpolar Grassland Formation (V.A.5.N.c). It is a natural/semi-natural vegetation unit. However, we mapped to the Formation level because this vegetation could not be linked to a plant community or alliance type. Goat prairies at EFMO cover small areas, always <0.25 ha (0.62 acres). Small areas as such are difficult to determine true plant associations because they are generally in transition to the surrounding plant communities.

This map class appears most often on south to southwest aspects and interfluves and has a woodland character. Tree species are sparse (<25%) and variable, but red-cedar and bur oak are usually present. Many of the herbaceous species are savanna and prairie species including asters, blazing star, side-oats grama, big bluestem, little bluestem, leadplant, and several species of native goldenrods. HGP expresses elements of other dryer plant community types described by other map classes, such as the white oak - chinquapin oak phase (FWO) of the Midwestern White Oak - Red Oak Forest map class and the hillside prairie phase (FHP) of the Chinquapin Oak Bluff Woodland map class.

Because goat prairie units at EFMO are all small in area and important to current land management efforts at EFMO, we mapped HGP to 0.1 ha (0.25 acres) MMU.

Bottomland Herbaceous Mix (HBF)

The Bottomland Herbaceous Mix (HBF) map class represents the Temporarily Flooded Temperate or Subpolar Grassland Formation (V.A.5.N.j). It is a natural/semi-natural vegetation unit. However, we mapped to the Formation level because this vegetation could not be linked to a plant community or alliance type.

This map class is composed of a variety of native and nonnative forbs and grasses of wet meadows, and has a weedy tendency. Dominant species include marsh aster, cow parsnip, milkweeds, and angelica. HBF is found along streams and ditches, and other disturbed wet areas. From viewing historic aerial photographs (dated summer 1989) of the area, it is probable some of these HBF stands within the Mississippi River floodplain near the Sny Magill Unit were once stands of swamp white oak. Because of extensive flooding over the past decade, these forests have deteriorated and fallen, allowing a rich mix of forbs and herbs to flourish.

Emergent Marsh Farm Pond (HEP)

The Emergent Marsh Farm Pond (HEP) map class represents the Seasonally Flooded Temperate or Subpolar Grassland Formation (V.A.5.N.k). We developed this map class to depict the diverse array of emergent vegetation common within these small man-made ponds, most being <0.25 ha (0.62 acres). These farm ponds are often in pasturelands and used by livestock for water, although only inundated a portion of the growing season. With high plant diversity within these farm ponds and their small size, vegetation does not necessarily fit NVCS plant community concepts.

All cases of the HEP map class are outside EFMO boundaries. Common emergent plants within these farm ponds are cattails, bulrushes, arrowhead, burreed, and reed canary grass. Because most are small in area, we mapped HEP to 0.1 ha (0.25 acres).

The Reed Canary Grass Eastern Marsh (HCG), River Bulrush Marsh (HRB), and Bulrush - Cattail - Burreed Shallow Marsh (HGB) map classes hierarchically list under the V.A.5.N.k Formation unit. However, HCG, HRB, and HGB are mapped separately as they each represent a plant community of the NVCS.

Representative picture is not available.

Submersed Aquatic Farm Pond (HSP)

The Submersed Aquatic Farm Pond (HSP) map class represents the Permanently Flooded Temperate or Subpolar Hydromorphic-rooted Vegetation Formation (V.C.2.N.a). We developed this map class to depict the diverse array of macrophytic vegetation common within these small farm ponds, most being <0.25 ha (0.62 acres). These farm ponds are often in pasturelands and used by livestock for water. Unlike the Emergent Marsh Farm Pond (HEP), these ponds normally are inundated throughout the growing season. With high plant diversity within these farm ponds and their small size, vegetation does not necessarily fit NVCS plant community concepts.

All cases of the HSP map class are outside EFMO boundaries. Common macrophyte plants within these farm ponds are submergent plants (including coontail), duckweed, and water lily. Because most are small in area, we mapped HSP to 0.1 ha (0.25 acres).

The Midwest Pondweed Submerged Wetland (HPW), American Lotus Aquatic Wetland (HAL), and Water Lily Aquatic Westland (HWL) map classes hierarchically list under the V.C.5.N.a Formation unit. However, HPW, HAL, and HWL are mapped separately as they each represent a plant community of the NVCS.

Representative picture is not available.

Conifer Plantation Forest (FCP)

The Conifer Plantation Forest (FCP) map class represents the Plantations (evergreen) Formation (I.A.8.C.a). The official NVCS name for this Formation unit is "Plantations (planted timber stands, Christmas trees)", which is the same name given to all forested plantations in the NVCS, regardless of evergreen or deciduous. We revised the name slightly to add clarity these plantations are indeed made up of evergreen trees. This Formation is a planted/cultivated type within the NVCS.

Most plantation forests are within the Iowa Yellow River State Forest, mostly within the Luster Heights Unit. These plantations are mostly of red pine and are a product of reforestation efforts by Iowa in the 1940s, converting most of their open lands to trees. Other planted trees function as shelterbelts protecting farmsteads and consist of pine or spruce.

A small plantation of white pine does exist bordering the Yellow River bottomlands. However, with this pine stand <0.25 ha (0.62 acres) in area (<MMU), the pine plantation is included in the surrounding polygon of Ash - Elm - Walnut - Hackberry Semi-natural Forest (FRH). All mapped polygons of FCP are outside EFMO lands.

Perennial Grass Crop (HPG)

The Perennial Grass Crop (HPG) map class represents the Perennial Grass Crops (hayland, pastureland) Formation (V.A.5.C.a). This Formation is a planted/cultivated type within the NVCS. HPG describes herbaceous lands of perennial grasses and forbs allowed to grow naturally, and either cut for hay or used for pasture. All HPG are located outside EFMO lands.

Crop Field (HCF)

The Crop Field (HCF) map class represents two NVCS Formations: Annual Close-grown Forbs and Grasses (V.D.2.C.a) and Annual Row-crop Forbs and Grasses (V.D.2.C.b). These Formations are planted/cultivated types within the NVCS. HCF describes lands cultivated for row crops (e.g., corn, soybeans) or improved pasture of monotypic annual or biennial herbaceous vegetation (e.g., alfalfa, clover). All HCF are located outside EFMO lands.

Descriptions of Map Classes Representing Non-vegetation Features

We derived eight map classes to represent open water and land use. These map classes by and large follow the descriptions as defined by Anderson et al. (1976) level II LULC classification. This classification was designed to meet the needs of Federal and state agencies for a uniform categorization of data from satellite and aircraft remote sensors. It uses a hierarchical system of four levels to fit the classifying needs from satellite type sensor data (Level I) to low-altitude photo imagery data (Level VI; <1:20,000-scale).

The USGS-NPS VMP uses Level II of this LULC classification system to classify general land cover conditions not defined by the NVCS natural/semi-natural or planted/cultivated types. These include populated areas, roads, quarries, and open water bodies. Full definitions on Level II are defined in the LULC publication.

Three map classes pertain to open water, and the other five depict general land use. We have organized these eight map classes into two categories. They are as follows:

- Upland Shrubland and Herbaceous Vegetation,
- Wetland Herbaceous Vegetation.

The three open water map classes define the open water non-vegetated (<10% vegetated) types. They are Open Water Farm Pond (OFP), Shallow Water and Mud Flat (OSM), and River and Stream (ORS).

The five land use map classes define man-made land use features. They are Residential (LRS), Commercial (LCM), Road and Railroad (LRR), Farmstead (LFB), and Quarry (LQR).

Open Water Farm Pond (OFP)

The Open Water Farm Pond (OFP) map class represents small farm ponds with <10% rooted vegetation. These farm ponds are man-made and primarily used for water by grazing livestock. When farm ponds are >10% vegetated, they are either Emergent Marsh Farm Pond (HEP) or Submersed Aquatic Farm Pond (HSP). All OFP are located outside EFMO lands. Because most are small in area, we mapped HSP to 0.1 ha (0.25 acres).

The LULC Level II unit best describing the OFP map class is Agricultural Land, Other Agricultural Land (24)

Shallow Water and Mud Flat (OSM)

The Shallow Water and Mud Flat (OSM) map class represents shallow waters and mud flats with <10% rooted vegetation and found along meandering oxbow channels bordering islands of the Mississippi River. OSM is closely associated to the River and Stream (ORS) map class.

Because of frequent changes in water depth in the Mississippi River's lock and dam system, annual plants often take root during opportunistic scenarios of water draw down. For those mud flat sparsely vegetated (<10%), the plant community most likely present is the River Mud Flats Sparse Vegetation (CEGL002314). Many mud flats remain without vegetation with as surface exposure comes late in the growing season. Many exposed mud flat areas on the October-dated photography are completely inundated on the August-dated photography.

We did not attempt to map the River Mud Flats Sparse Vegetation plant community. Adequately detecting vegetation of <10% on aerial photographs is difficult, but when it exists it most reasonably is captured with OSM.

The LULC Level II unit best describing the OSM map class is Water, Streams and Canals (51).

Representative picture is not available.

River and Stream (ORS)

The River and Stream (ORS) map class represents open water rivers and streams, namely the Yellow and Mississippi Rivers. Sparse aquatic submergent vegetation may be present, but <10% vegetation and usually in shallower waters closer to shorelines or in transition into beds of aquatic macrophytes. If sparse vegetation appears within ORS, we presume vegetation similar to those represented by the Midwest Pondweed Submerged Wetland (HPW), American Lotus Aquatic Wetland (HAL), and Water Lily Aquatic Wetland (HPW) map classes for ORS within the Mississippi River floodplain. We presume either filamentous algae or buttercup vegetation for ORS within the Yellow River.

The LULC Level II unit best describing the ORS map class is Water, Streams and Canals (51).

Residential (LRS)

The LULC Level II unit best describing the Residential (LRS) map class is the Urban Built-up Land, Residential unit (11). LRS describes lands used primarily for residential purposes in populated areas or rural settings, with the exception of farmsteads. All LRS are outside EFMO lands.

Commercial (LCM)

The LULC Level II unit best describing the Commercial (LCM) map class is the Urban Built-up Land, Commercial and Services unit (12). LCM describes lands used primarily for commercial purposes in populated areas or rural settings, again, with the exception of farmsteads. The park headquarters and visitor center is included in this map class.

Road and Railroad (LRR)

The LULC Level II unit best describing the Road and Railroad (LRR) map class is the Urban Built-up Land, Transportation, Communications, and Utilities unit (14). LRR describes lands used primarily for transportation including roads and right-of-ways, railroads, and roadside parking.

Farmstead (LFB)

The LULC Level II unit best describing the Farmstead (LFB) map class is the Agricultural Land, Other Agricultural Land unit (24). LFB describes lands used primarily for farmsteads, including out buildings and farm ponds. However, we classified farm ponds having >10% vegetation as either as Emergent Marsh Farm Pond (HEP) or Submersed Aquatic Farm Pond (HSP). And, we classified farm ponds distant from the immediate farmstead premises as Open Water Farm Pond (OFP). All LFB are outside EFMO lands.

Representative picture is not available.

Quarry (LQR)

The LULC Level II unit best describing the Quarry (LQR) map class is the Barren Land, Strip Mines, Quarries, and Gravel Pits unit (75). LQR describes lands used for extractive mining purposes, whether active or nonactive). The only quarry we mapped is located west of the Sny Magill Unit.

Representative picture is not available.

Appendix H

Example of an Accuracy Assessment Form

USGS-NPS Vegetation Mapping Program
Accuracy Assessment Form

Effigy Mounds National Monument, 2002

AA# 084	**Park Code: EFMO**	**Date:** 09-03-02	**Observers:** SJL
UTM Easting 644.441 **Offset (m):**		**UTM Northing** 4774.710 **Offset (m):** ±	
Picture no(s) 100 - 1083		± 3.3m	

SETTING

Topography: interfluve	**Location:** Yel. R. State forest
Aspect: flat	**Elevation:** 870'
Soil Texture: sandy silt	**Slope:** flat
Drainage: good	**Setting comments:** Near Juniper pt.

STRUCTURE AND COMPOSITION

	Stratum	Major Species Present with %RD of Each.	Height (m)	% Cover of Layer	Cover Patchy or Uniform?
T1	Emergent				
T2	Canopy	Que mac Que alb	50'	50%	patchy
T3	Subcanopy (<10cm dbh)	Car ova Ost vir	7m	01%	patchy
S1	Tall Shrub (2 – 5 m)	Ost vir	4m	10%	patchy
S2	Short Shrub (<2 m)	Ost vir Ace sac Xan ame Car cor	1m	15%	patchy
H	Herbaceous	sol ulm gal bor Ast sho Hys pnt car con pol can	<0.5m	80%	uniform
V	Vine/Liana				

Indicator spp:	**Rare spp:**

MAP CLASS AND VEGETATION TYPE

Map Class Code: FWO	**Veg Type Code:**
Alternate Map Class: —	**Alternate Veg Type Code:**
Map Class # 2 w/in 50 m plot: FRC	**Veg Type # 2 w/in 50 m plot:**
Map Class # 3 w/in 50 m plot: FOH	**Veg Type # 3 w/in 50 plot:**

Comments (note influences on the vegetation (e.g. logging), difficulties with classification, if any, influences of topography)
high Short shrub cover of ost, very shirt maples coming in too.

Appendix I

Accuracy Assessment Contingency Matrix

Explanation of the Contingency Matrix

The accuracy assessment contingency matrix for the Effigy Mounds National Monument vegetation map (Table I-1) is an array of numbers set out in rows and columns which reveal the number of polygons assigned to a particular plant community relative to the actual plant community as verified on the ground. The columns represent National Vegetation Classification System (NVCS) associations (plant communities) as per NatureServe (2003) listed by their Community Global Element (CEGL) code, and the rows represent the map classes listed by their map class codes. The accuracies of each map class are described as both producers' accuracy with errors of inclusion (omission errors), and users' accuracy with error of exclusion (commission errors) present in the mapping.

We provide a key to the names of map class and plant community CEGL codes below the matrix table.

Table I-1. Accuracy Assessment Contingency Matrix for the Effigy Mounds National Monument Vegetation Map.

CODES	AA	2062	5239	2068, 2144	2144	2203	2586	2018	8562	2190	6044	2221	2026	5240	2282	4323	2386	TOTAL	USERS' ACCUR-ACY	Confidence Intervals -/+		Kappa (P Column)
MAP																				-	+	
FOM, FMB, FNO, FOX, FOB, FMH		106	4	1														111	95%	92%	99%	0.331
FRH			20															20	100%	98%	103%	0.060
FWO, FOH, FSH, FBA, FTA		2		62														64	97%	93%	101%	0.191
FRC, FHP		1			15													16	94%	81%	107%	0.048
HRP						3												3	100%	83%	117%	0.009
FMC, FEH, FSW, FBO			2				36	4										42	86%	76%	96%	0.125
FCW							1	1										2	50%	-33%	133%	0.006
SWL									2									2	100%	75%	125%	0.006
SBB										3								3	100%	83%	117%	0.009
HCG							1				22			1				24	92%	80%	103%	0.072
HRB												4						4	100%	88%	113%	0.012
HGB													2					2	100%	75%	125%	0.006
HRC, HBA														14	1			15	93%	79%	107%	0.045
HPW														1	12	5	1	19	63%	42%	84%	0.057
HAL																5		5	100%	90%	110%	0.015
HWL															1	1	1	3	33%	-28%	95%	0.009
TOTAL		109	26	63	15	3	38	5	2	3	22	4	2	16	14	11	2	335				
PRODUCERS' ACCURACY		97%	77%	98%	100%	100%	95%	20%	100%	100%	100%	100%	100%	88%	86%	45%	50%					
Confidence Interval -		94%	61%	95%	97%	83%	87%	-19%	75%	83%	98%	88%	75%	71%	67%	16%	-33%					
Confidence Interval +		100%	92%	102%	103%	117%	102%	59%	125%	117%	102%	113%	125%	104%	105%	75%	133%					
Kappa (P Row)		0.325	0.078	0.188	0.045	0.009	0.113	0.015	0.006	0.009	0.066	0.012	0.006	0.048	0.042	0.033	0.006					
Kappa		0.108	0.005	0.036	0.002	0.000	0.014	0.000	0.000	0.000	0.005	0.000	0.000	0.002	0.002	0.000	0.000	0.175				
Overall Accuracy = 92%		Kappa adjustment = 90%																				

KEY TO MAP CLASS CODES
(via order on matrix)

FOM	North-central Maple - Basswood Forest (east-facing maple phase)
FMB	North-central Maple - Basswood Forest (north-facing maple phase)
FNO	North-central Maple - Basswood Forest (north-facing red oak phase)
FOX	North-central Maple - Basswood Forest (disturbed oak phase)
FOB	North-central Maple - Basswood Forest (disturbed maple - basswood phase)
FMH	North-central Maple - Basswood Forest (disturbed hardwoods phase)
FRH	Ash - Elm - Walnut - Hackberry Semi-natural Forest
FWO	Midwestern White Oak - Red Oak Forest (white oak - chinquapin oak phase)
FOH	Midwestern White Oak - Red Oak Forest (oak - hickory phase)
FSH	Midwestern White Oak - Red Oak Forest (shagbark hickory phase)
FBA	Midwestern White Oak - Red Oak Forest (bigtooth aspen phase)
FTA	Midwestern White Oak - Red Oak Forest (trembling aspen phase)
FRC	Chinquapin Oak Bluff Woodland (red-cedar phase)
FHP	Chinquapin Oak Bluff Woodland (hillside prairie phase)
HRP	Central Mesic Tallgrass Prairie
FMC	Silver Maple - Elm - (Cottonwood) Forest (maple phase)
FEH	Silver Maple - Elm - (Cottonwood) Forest (hackberry phase)
FSW	Silver Maple - Elm - (Cottonwood) Forest (swamp white oak phase
FBO	Silver Maple - Elm - (Cottonwood) Forest (bur oak phase)
FCW	Eastern Cottonwood - Black Willow Forest
SWL	Sandbar Willow Shrubland
SBB	Northern Buttonbush Swamp
HCG	Reed Canary Grass Eastern Marsh
HRB	River Bulrush Marsh
HGB	Bulrush - Cattail - Burreed Shallow Marsh
HRC	Arrowhead - Rice Cutgrass Marsh (rice cutgrass phase)
HBA	Arrowhead - Rice Cutgrass Marsh (arrowhead phase)
HPW	Midwest Pondweed Submerged Wetland
HAL	American Lotus Aquatic Wetland
HWL	Water Lily Aquatic Wetland

KEY TO CEGL CODES
(via order on matrix)

2062	North-central Maple - Basswood Forest
5239	Ash - Elm - Walnut - Hackberry Semi-natural Forest
2068	Midwestern White Oak - Red Oak Forest
2144	Chinquapin Oak Bluff Woodland
2203	Central Mesic Tallgrass Prairie
2586	Silver Maple - Elm - (Cottonwood) Forest
2018	Midwestern Cottonwood - Black Willow Forest
8562	Sandbar Willow Shrubland
2190	Northern Buttonbush Swamp
6044	Reed Canary Grass Eastern Marsh
2221	River Bulrush Marsh
2026	Bulrush - Cattail - Burreed Shallow Marsh
5240	Arrowhead - Rice Cutgrass Marsh
2282	Midwest Pondweed Submerged Aquatic Wetland
4323	American Lotus Aquatic Wetland
2386	Water Lily Aquatic Wetland