National Park Service
U.S. Department of the Interior

Northeast Region
Philadelphia, Pennsylvania

Vegetation Classification and Mapping at Fort Necessity National Battlefield

Technical Report NPS/NER/NRTR--2006/038

ON THE COVER
Successional Old Field in the Great Meadows of Fort Necessity National Battlefield Main Unit.
Photograph by: Ephraim Zimmerman.

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Technical Report NPS/NER/NRTR--2006/038

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April 2006

U.S. Department of the Interior
National Park Service
Northeast Region
Philadelphia, Pennsylvania

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This report was accomplished under Cooperative Agreement 4560A0019, Amendment Numbers 3 and 11, with assistance from the NPS. The statements, findings, conclusions, recommendations, and data in this report are solely those of the author(s), and do not necessarily reflect the views of the U.S. Department of the Interior, National Park Service.

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Please cite this publication as:

Perles, S. J., G. S. Podneisinski, E. A. Zimmerman, W. A. Millinor, L. A. Sneddon. April 2006. Vegetation Classification and Mapping at Fort Necessity National Battlefield. Technical Report NPS/NER/NRTR--2006/038. National Park Service. Philadelphia, PA.

NPS D-200 April 2006

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Acknowledgments

We would like to thank the following people for their time and assistance with this project. Connie Ranson of the National Park Service provided us with previous research conducted at Fort Necessity, expertise on ongoing management practices, and access for sampling within the park. John Kunsman and Susan Klugman of the Pennsylvania Natural Heritage Program contributed valuable botanical and geographic information system expertise, respectively. Robert Coxe, Jessica McPherson, Charles Bier, Alice Doolittle, and Steve Grund from the Pennsylvania Natural Heritage Program previously worked on inventory and mapping projects at Fort Necessity. Their work was extremely beneficial to this project. In addition, Matthew Sarver and Lindsey Miller were of great assistance during data collection. The contributions of these individuals are greatly appreciated.

Executive Summary

Vegetation classification and mapping was conducted for Fort Necessity National Battlefield, creating a current digital geospatial vegetation database for the park. Eight vegetation associations, Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, Sugar Maple – Basswood Forest, Tuliptree Forest, Red Maple – Black Cherry Successional Forest, Conifer Plantation, Successional Old Field, and Wet Meadow, that occur within the park were identified and described in detail.

A high rate of error was calculated in the thematic mapping of three of the park's common deciduous hardwood forest associations: The Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, and Tuliptree Forest. This error can be attributed to the diverse topography and land use history of the southwestern corner of the park's Main Unit. The influences of previous land uses can also be seen in the Red Maple – Black Cherry Successional Forest and Conifer Plantations. The Sugar Maple – Basswood Forest is restricted to a small area of the Jumonville Glen where the underlying limestone geology has contributed to the establishment and growth of plant species that require rich soil conditions.

The Successional Old Field and Wet Meadow associations in the Main Unit of Fort Necessity National Battlefield are important natural and cultural resources. These vegetation types provide visitors with the landscape context for the historic battles and also provide habitat to numerous birds, moths, butterflies, and dragonflies.

A map showing the locations of these associations in the park was created following the USGS/NPS Vegetation Mapping Program protocols (The Nature Conservancy and Environmental Systems Research Institute 1994a, b, c). A dichotomous field key was developed for these vegetation associations to assist with field recognition and classification. These vegetation associations were also crosswalked to the National Vegetation Classification System in order to provide a regional context for the park's vegetation.

Recommendations for the management of these vegetation associations are discussed, including invasive species management, control of woody species in open fields, restoration of Great Meadow Run, and establishment of oak regeneration. This project documents the vegetation associations of Fort Necessity National Battlefield based on 2003 aerial photography and field sampling, and completes one of 12 basic inventory data sets for the park.

Keywords: vegetation association, classification and mapping, Fort Necessity National Battlefield.

Introduction

General Background

One of the goals of the National Park Service (NPS) Inventory and Monitoring Program is to provide the information and expertise needed by park managers for effective, long-term management of the natural resources held in trust (National Park Service 2003). The program recommends that 12 basic natural resource inventories be developed for each park that contains significant natural resources. These inventories provide crucial baseline information needed for proper park natural and cultural resource stewardship. A map of each park's current vegetation based on aerial photography less than five years old is one of the 12 inventories recommended by the program (National Park Service 2003). To ensure that vegetation mapping is standardized across the National Park Service (NPS), The Nature Conservancy, in conjunction with NatureServe, the Federal Geographic Data Committee, and the Ecological Society of America Vegetation Subcommittee, developed a protocol for creating vegetation maps in national parks. This protocol was adopted by the United States Geological Survey (USGS)/NPS Vegetation Mapping Program as the standard (The Nature Conservancy and Environmental Systems Research Institute 1994a, b, c) and has been implemented at Fort Necessity National Battlefield by the Pennsylvania Natural Heritage Program.

The goal of the mapping effort at Fort Necessity National Battlefield was to produce an up-to-date digital geospatial vegetation database for the park and to provide a plant species list, a dichotomous key for vegetation associations, and descriptions of the vegetation associations in the park. Baseline information on plant community composition and rarity is critical to developing desired conditions and park management goals relating to native plant communities, nonnative plant and insect species, or effects of deer browse and other disturbances. The identification and description of plant communities also provide habitat information important to understanding associated organisms, including animals, protozoans, bacteria, and fungi. A map of vegetation communities may allow inferences about the location and abundance of species that are characteristic of each community.

This report also describes the park's vegetation in the context of a regional and national vegetation classification. The Nature Conservancy, in conjunction with NatureServe, the Federal Geographic Data Committee, and the Ecological Society of America Vegetation Subcommittee, developed the National Vegetation Classification System (NVCS) in order to standardize vegetation classification and facilitate the comparison of vegetation types throughout the United States and internationally. The NVCS is a systematic approach to classifying existing natural vegetation using physiognomics and floristics (Grossman et al. 1998).

The NVCS has a hierarchical structure. The basic unit of vegetation classification in the NVCS is the association. An association is defined as a plant community type that is relatively homogeneous in composition and structure and occurs in a uniform habitat. For example, Northeastern Dry Oak - Hickory Forest is a common association typically found on well-drained soils on upper and midslopes in southwestern Pennsylvania. Associations are also assigned global rarity ranks that indicate their conservation status and relative risk of extirpation (Grossman et al. 1998).

Several associations that share one or more dominant or characteristic species can be grouped to form an alliance. Alliances are generally more wide-ranging geographically than associations, covering multiple habitats and broader species composition. For example, the Northeastern Dry Oak - Hickory Forest association mentioned previously is grouped with other similar dry oak forest associations into the (White Oak, Northern Red Oak, Black Oak) / Flowering Dogwood / Mapleleaf Viburnum Forest Alliance. An association with an unique species composition or environmental niche can be assigned to its own alliance, such that the alliance only contains one association instead of multiple associations.

One level above alliance is the formation, representing vegetation types that share a common physiognomy within broadly defined environmental factors (Grossman et al. 1998). For example, Lowland or Submontane Cold-Deciduous Forest is a common formation that encompasses most of the hardwood forest types in the northeastern and midwestern United States, including the White Oak (Northern Red Oak, Black Oak) / Flowering Dogwood / Mapleleaf Viburnum Forest Alliance mentioned above. Formation level vegetation types can be determined through aerial photointerpretation and their delineation within a park is one of the first steps in vegetation mapping.

Park-specific Information

The Fort Necessity battlefields were designated as a National Battlefield Site by the U.S. War Department on March 4, 1931. The land was transferred to the National Park Service on August 10, 1933 and was designated a National Battlefield on October 26, 1974. The park preserves the land on which the opening battle, George Washington's first major military combat, of the French and Indian War occurred, and two other associated sites. The park covers 373 ha (921 ac) and consists of three units: the Main Unit (353 ha [872 ac]), Jumonville Glen (11 ha [27 ac]), and Braddock's Grave (9 ha [22 ac]). Over 90,000 people visit Fort Necessity National Battlefield each year (National Park Service 2004).

Project Area

Location and Regional Setting

Set in the Allegheny Mountains of southwestern Pennsylvania, Fort Necessity National Battlefield is located 17.7 km (11 mi) east of Uniontown, PA along U.S. Route 40, the historic National Road. The park is located in Fayette County between the Youghiogheny and the Monongahela rivers. This area of the county falls within the Allegheny Mountain section of the Appalachian Plateau physiographic province. The prominent features of this section are two anticlines (rock folded convex upward, resembling an arch), Laurel Hill and Chestnut Ridge (Schultz 1999). The Main Unit and the Braddock's Grave Unit are situated in the shallow upland valley between Laurel Hill and Chestnut Ridge. Locations of the three units of Fort Necessity National Battlefield are shown in Figure 1. The Main Unit and the Braddock's Grave Unit fall within the Fort Necessity, PA USGS topographic quad map. The Jumonville Glen Unit lies within the Uniontown, PA USGS topographic quad map.

In Fayette County, the ridgelines of Laurel Hill and Chestnut Ridge support large contiguous blocks of forest (Wagner and Coxe 2000). These forests were dominated by the American chestnut (*Castanea dentata*) until the 1930s, but were replaced by oak (*Quercus* spp.) after the chestnut blight. In recent years, these forests have suffered from the widespread loss of oak due to gypsy moth (*Lymantria dispar*) infestations in the late 1980s and early 1990s. These forests have also experienced several rounds of logging in the last two centuries. Currently, the dominant trees on the ridges include chestnut oak (*Quercus prinus*), black oak (*Quercus velutina*), white oak (*Quercus alba*), and northern red oak (*Quercus rubra*), with associates red maple (*Acer rubrum*), sweet birch (*Betula lenta*), black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), and tuliptree (*Liriodendron tulipifera*). These forests typically contain ericaceous shrubs such as mountain laurel (*Kalmia latifolia*), great laurel (*Rhododendron maximum*), and species of blueberry (*Vaccinium* spp.). Dense layers of greenbrier (*Smilax* spp.) and/or eastern hayscented fern (*Dennstaedtia punctilobula*) can develop in canopy openings created by logging or extensive gypsy moth-induced mortality (Wagner and Coxe 2000).

On the middle and lower slopes of the Allegheny Mountains higher moisture levels and deeper soils create increased diversity of vegetation. Red oak, black oak, white oak, shagbark hickory (*Carya ovata*), pignut hickory (*C. glabra*), bitternut hickory (*C. cordiformis*), black cherry, red maple, sugar maple (*Acer saccharum*), tuliptree, American elm (*Ulmus americana*), slippery elm (*U. rubra*), American basswood (*Tilia americana*), and white ash (*Fraxinus americana*) are common canopy trees. Shrubs such as American witchhazel (*Hamamelis virginiana*), cucumber-tree (*Magnolia acuminata*), and northern spicebush (*Lindera benzoin*) become more prominent on the middle and lower slopes. The heath layer typical of ridgetops and upper slopes is replaced by ferns and other herbaceous species at lower elevations, and the ground cover generally becomes more diverse.

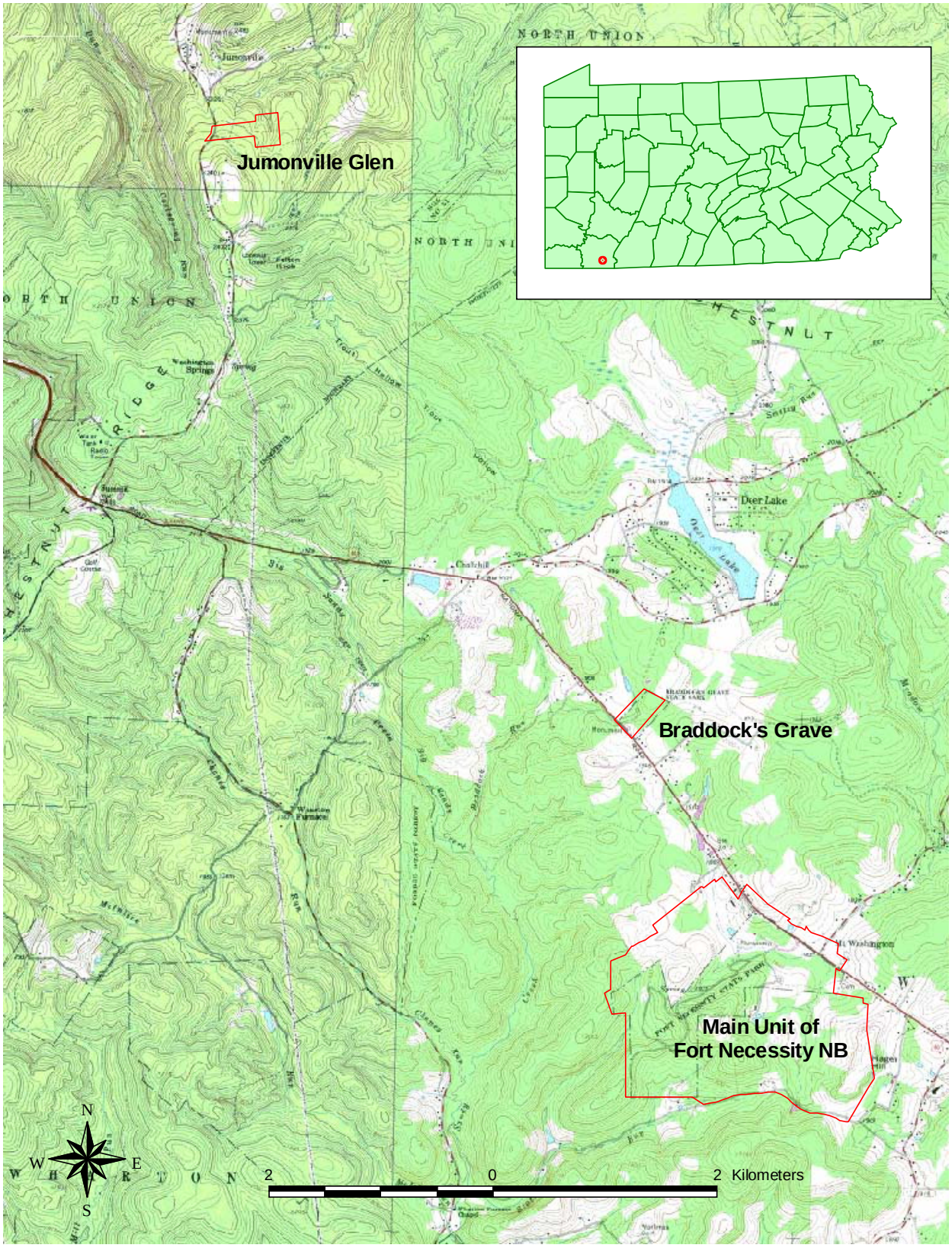

Figure 1. Location of the three units of Fort Necessity National Battlefield, Fayette County, Pennsylvania, on the Fort Necessity and Uniontown 1:24,000 USGS topographic quad maps.

Park Environmental Attributes

Many environmental factors, such as geology, topography, soils, and hydrology, affect the types and distribution of vegetation within Fort Necessity National Battlefield. Under the Main Unit and the Braddock's Grave Unit the bedrock geology is the Glenshaw Formation, a marine-derived sediment of Pennsylvanian age that is composed of acid shale and sandstone, with limited amounts of limestone and coal. The Jumonville Glen Unit is located on Burgoon Sandstone, a crossbedded, medium- to coarse-grained acid sandstone of Mississippian age.

Since the park is located on a plateau, there are no drastic changes in elevation within the park boundaries. Elevation within the Main Unit of the park ranges from 560–640 m (1,837–2,100 ft). The Jumonville Glen Unit is located between 670–715 m (2,198–2,346 ft). The Braddock's Grave Unit is relatively level, with elevation change only between approximately 580–595 m (1,903–1,952 ft).

The valley between Laurel Hill and Chestnut Ridge is largely characterized by soils of the Gilpin-Wharton-Ernest association in low parts of the valley and the Dekalb-Hazelton-Cookport association in higher elevations. In the Main Unit and the Braddock's Grave Unit, Wharton silt loam, Gilpin channery silt loam, and Gilpin-Weikert channery silt loam are common well-drained soils associated with upland fields and forest. Ernest, Brinkerton, and Armagh silt loams are poorly-drained soils associated with mesic forests and wet meadows in the southern two units of the park. Philo silt loam, a moderately well-drained floodplain soil, is common along stream drainages in the park's Main Unit. At the Jumonville Glen Unit and on the hilltops of the Main Unit, Hazelton channery loam, a well-drained and often stony soil, is common (Kopas 1991).

Four streams are located within the park's boundaries. Braddock Run flows through the southwestern portion of the Braddock's Grave Unit. The headwaters of Scott Run originate in the western portion of the Main Unit and flow south out of the park. Indian Run flows south through the Great Meadows into Great Meadow Run. Great Meadow Run originates just outside the park's Main Unit upstream of the Great Meadows. It flows through the Great Meadows and exits northward out of the Main Unit, eventually joining the Youghiogheny River.

Materials and Methods

Planning and Scoping

Several steps were taken to prepare for the mapping and classification of vegetation at Fort Necessity National Battlefield. A planning and review meeting was held on June 19, 2003 with ecologists from the Pennsylvania Natural Heritage Program (both the Pennsylvania Science Office of The Nature Conservancy and the Western Pennsylvania Conservancy), National Park Service (NPS) resource managers, and NatureServe staff. The project timeline, access issues, park resource management needs, current vegetation management, vegetation associations of special interest, and applicable previous research conducted at the park were discussed. In addition, reconnaissance of the park's vegetation types was conducted to estimate the number and distribution of vegetation associations in the park.

Preliminary Data Collection and Review of Existing Information

Previous studies conducted at Fort Necessity National Battlefield were obtained from the park's natural resource manager and reviewed for information pertinent to the park's vegetation. Numerous botanical surveys, a bird survey, a wetland delineation report, and records of species of special concern were examined (Mace 1973; Botanical Society of Western Pennsylvania 1985; Andrew Martin Associates 1992; Ranson 1998; Yahner et al. 2004). In addition, previous vegetation mapping and inventory work conducted by the Western Pennsylvania Conservancy was reviewed to inform the current mapping project (Western Pennsylvania Conservancy 2003).

Aerial Photography Acquisition and Processing

Color infrared, stereo pair 1:6,000 scale aerial photography for a digital orthophoto mosaic of Fort Necessity National Battlefield was acquired from an overflight on April 13, 2003 (i.e., during leaf-off conditions) by Kucera International. The photography was delivered to the National Park Service (NPS), quality checked, accepted as provided, and sent to North Carolina State University (NCSU). Upon receipt at NCSU, the air photos were counted to make sure that none were missing, scanned, and placed in the air photo archive maintained at NCSU for the NPS Northeast Region Inventory & Monitoring Program. Associated data and information provided by Kucera, and also stored in the air photo archive, include the airborne GPS/IMU files, the camera calibration certificate for the camera, and the hardcopy flight report for the photography that crosswalks the airborne GPS/IMU data to the photo frame numbers.

The mosaic was produced from 41 color infrared air photos scanned at 1200 dpi with 24-bit color depth. The scanned images of the air photos were imported into ERDAS Imagine (.img) format where a photo block was created using airborne GPS and IMU data that Kucera International supplied with the aerial photography. The photo block was manipulated until it could be triangulated with a root mean square error of less than one. At this point, single frame orthophotos (one for each air photo) were generated within Imagine and exported to Imagine .lan format. Then the .lan files were imported into ER Mapper's native (.ers) format, and an ER Mapper algorithm was created which contains the color balancing information and the cutlines created for the final mosaic. In ER Mapper a band interleaved by line (.bil) image and header file of the final mosaic was generated, the .bil image was imported into Imagine .img format,

and, finally, the .img image was compressed using MrSID software with a 20:1 compression ratio. Key information for the Fort Necessity National Battlefield mosaic is summarized in Table 1.

A metadata record for the mosaic was prepared according to current Federal Geographic Data Committee standards (FGDC 1998a). Metadata were produced in notepad and parsed using the USGS metadata compiler program (MP) to locate errors and omissions (USGS 2004). After all errors and omissions were corrected, MP was used to generate final TXT, HTML, and XML versions of each metadata record which are stored in the air photo archive.

Photointerpretation

After receiving the digital orthophoto mosaic from North Carolina State University, ecologists at the Pennsylvania Natural Heritage Program developed a formation-level vegetation map. Aerial photointerpretation was informed by viewing the diapositives through a stereoscope, viewing the digital mosaic onscreen, and overlaying the formation-level polygons onto digital topographic quad maps. Polygons were digitized onscreen using ArcView 3.2a (Environmental Systems Research Institute, Inc. 1992–2000) and the polygons were attributed with formation-level vegetation types from the National Vegetation Classification System. An aerial photography interpretation key to the formation-level vegetation types is shown in Appendix A. The resulting map (Figure 2) identified 108 polygons each labeled with one of eight different formation-level vegetation types or three modified Anderson level II categories (Table 2) (Anderson et al. 1976). The total area listed in Table 2 exceeds the park area of 373 ha (921 ac) because mapped polygons extend beyond the park boundaries. The formation-level map was then used to guide the vegetation sampling in the park and provided a broad overview of park vegetation.

Field Data Collection and Classification

All vegetation plot sampling followed the USGS/NPS Vegetation Mapping Program protocols (The Nature Conservancy and Environmental Systems Research Institute 1994b). The protocol suggests that each vegetation association should be sampled at least three times in order to capture the naturally occurring variation within the park. If each of the eight identified formations (Table 2) included only one association in Fort Necessity National Battlefield, then the minimum number of plots needed would have been 22. This assumed that polygons labeled with modified Anderson level II categories would not be sampled and that for formations with less than three polygons, one plot would be placed in each polygon.

Based on the initial reconnaissance and previous vegetation mapping efforts of the park, it was determined that the Lowland or submontane cold-deciduous forest formation included multiple vegetation associations, thereby requiring more sampling effort. Conversely, some formations such as Mixed needle-leaved evergreen - cold-deciduous forest, Conical-crowned temperate evergreen forest, and Conical-crowned temperate evergreen woodland applied to a single association, thereby requiring less sampling effort. Considering these factors, 45 polygons, stratified across formations, biophysical environments, and aerial photography signatures, were selected for sampling (Table 2). Since Fort Necessity National Battlefield was classified as a medium-sized park, the sampling area encompassed the entire park and representative polygons of each formation-level vegetation type were selected for sampling.

Table 1. Summary of key information for the Fort Necessity National Battlefield mosaic

Title of metadata record:	Fort Necessity National Battlefield Color Infrared Orthorectified Photomosaic (ERDAS Imagine IMG and Mr.SID formats)
Publication date of mosaic (from metadata):	September 15, 2004
Date aerial photography was acquired:	April 13, 2003 (leaf-off)
Vendor that provided aerial photography:	Kucera International
Scale of photography:	1:6,000
Type of photography:	Color infrared, stereo pairs
Number of air photos delivered:	41
Archive location of air photos, airborne GPS/IMU files, camera calibration certificate, and hardcopy flight reports:	North Carolina State University, Center for Earth Observation
Scanning specifications:	1200 dpi, 24-bit color depth
Horizontal positional accuracy of mosaic:	1.19 meters, meets Class 1 National Map Accuracy Standard
Number of ground control points upon which estimated accuracy is based:	49
Method of calculating positional accuracy:	Root Mean Square Error (RMSE)
Archive location of mosaic and metadata:	North Carolina State University, Center for Earth Observation
Format(s) of archived mosaic:	.img (uncompressed); MrSID (20:1 compression)

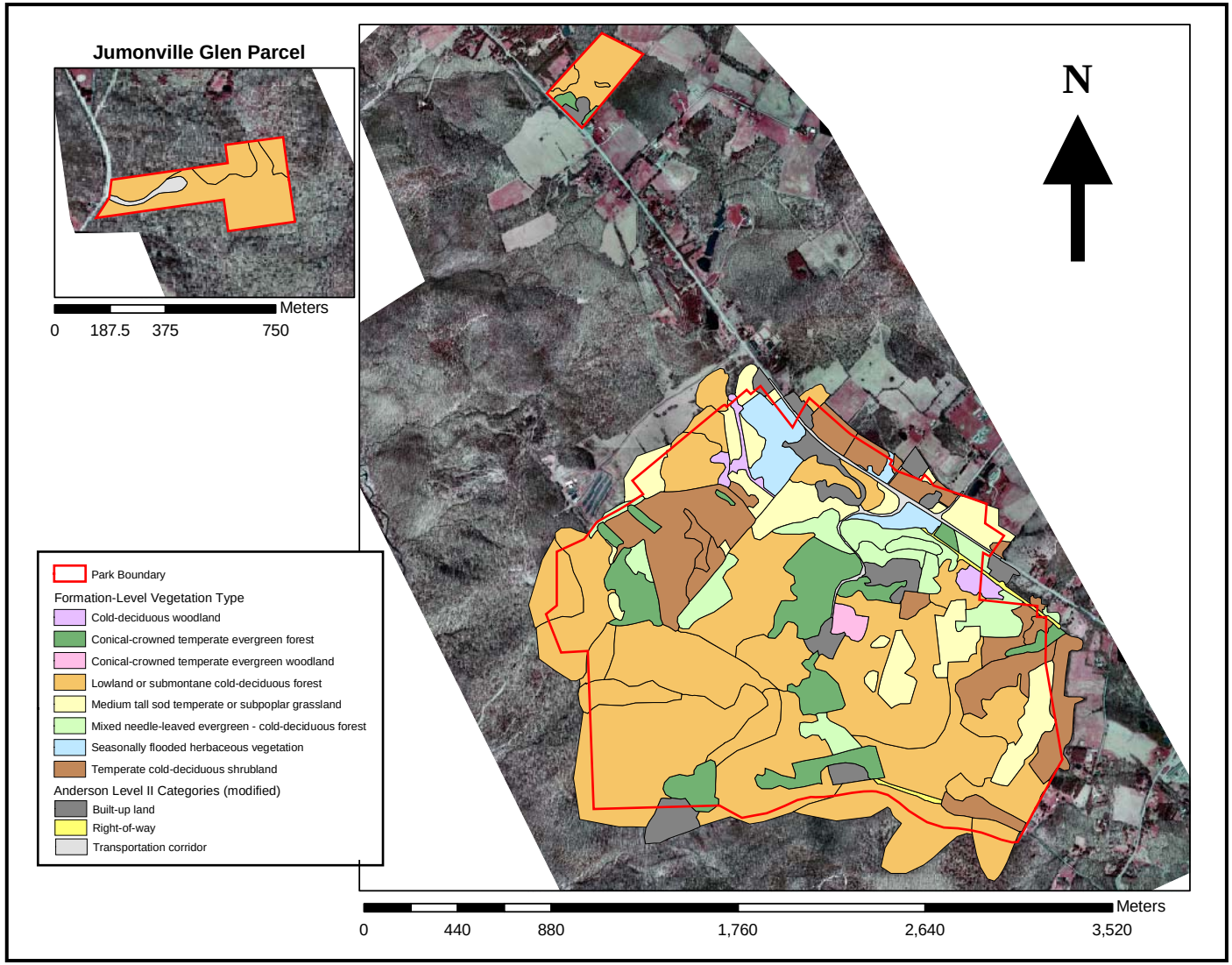

Figure 2. Formation-level vegetation types and Anderson level II categories (modified) for Fort Necessity National Battlefield.

Table 2. Number of polygons, total mapped hectares, hectares mapped within the park boundary, and number of plots sampled for formation-level vegetation types and Anderson level II categories (modified) at Fort Necessity National Battlefield.

	Number of Polygons	Total Mapped Hectares	Mapped Hectares Within Park Boundary	Number of Plots Sampled
Formation-Level Vegetation Type				
Cold-deciduous woodland	3	4.3	3.4	1
Conical-crowned temperate evergreen forest	13	35.8	35.0	4
Conical-crowned temperate evergreen woodland	1	2.1	2.1	1
Lowland or submontane cold-deciduous forest	30	232.2	198.0	20
Medium tall sod temperate or subpoplar grassland	19	39.5	34.7	6
Mixed needle-leaved evergreen - cold-deciduous forest	12	53.5	25.2	3
Seasonally flooded herbaceous vegetation	3	11.5	10.8	4
Temperate cold-deciduous shrubland	15	53.1	46.1	8
Anderson Level II Category (modified)				
Built-up land	11	19.5	12.9	0
Right-of-way	2	1.8	1.2	0
Transportation corridor	2	3.8	3.6	0
Total	111	457.2	373.0	47

Field Survey

Within each polygon selected for sampling, a plot was established in an area most representative of the existing vegetation (Mueller-Dombois and Ellenberg 1974). All vegetation data were collected following standard plot releve sampling protocols recommended by NatureServe (Strakosch-Walz 2000), with 20-m × 20-m (65-ft × 65-ft) plots in forests and woodlands, 10-m × 10-m (32-ft × 32-ft) plots in shrublands, and 5-m × 5-m (16-ft × 16-ft) plots in herbaceous vegetation. The plot sampling data form used in this project is shown in Appendix B. The vegetation was visually divided into 8 strata: emergent trees (variable height), tree canopy (variable height), tree subcanopy (>5 m [16 ft] in height), tall shrub (2–5 m [6–16ft]), short shrub (<2 m [6 ft]), herbaceous, non-vascular, and vines. The percent cover was estimated for each species in each stratum using modified Braun – Blanquet cover classes (Strakosch-Walz 2000). Specimens of species that were not identifiable in the field were collected for later identification. In addition to floristic information, the following environmental variables were recorded at each plot: slope, aspect, topographic position, hydrologic regime, soil stoniness, average soil texture, and soil drainage. Any unvegetated area of the plot was characterized by the exposed substrate. Notes were taken on the plot representativeness to the surrounding vegetation and any other significant environmental information, such as landscape context, herbivory, stand health, recent disturbance, or evidence of historic disturbance. The vegetation profile and topographic position were sketched in cross-section to represent the location and setting of the plot. A digital photograph of each plot was also taken. The location of each plot was recorded with a Trimble GeoXM global positioning system (GPS) unit, with the datum set to North American 1983 (Conus) and the coordinate system set to Universal Trans-Mercator (UTM) zone 17.

Plot sampling was conducted between June and September 2003. In total, 47 plots were sampled throughout the three units of Fort Necessity National Battlefield (Figure 3). All mapped vegetation types were sampled over a range of environmental variables. Two additional plots were placed in vegetation types (Sugar Maple – Basswood Forest and Wet Meadow) that were not sufficiently captured by the original sampling strategy.

Vegetation Classification and Characterization

Data from the 47 vegetation plots were then entered into the NatureServe PLOTS 2.0 Database System on a Microsoft Access platform during the fall of 2003. In the PLOTS 2.0 database, species were assigned standardized codes based on the PLANTS Database, Version 3.5, developed by the Natural Resource Conservation Service in cooperation with the Biota of North America Program (United States Department of Agriculture, National Resources Conservation Service 2004). For this report, some common names listed in the PLANTS Database, Version 3.5, were changed to reflect the common names typically used by ecologists and resource managers in this region. The common and scientific names of plants observed during the vegetation plot sampling are listed in Appendix C. Some tree and shrub seedlings and immature herbaceous plants could only be identified to the genus level and are therefore listed in the appendix as such. Environmental variables and species percent cover data were exported from the PLOTS database into Excel in order to be manipulated into a format compatible with PC-ORD version 4.0 Multivariate Analysis software (McCune and Mefford 1999).

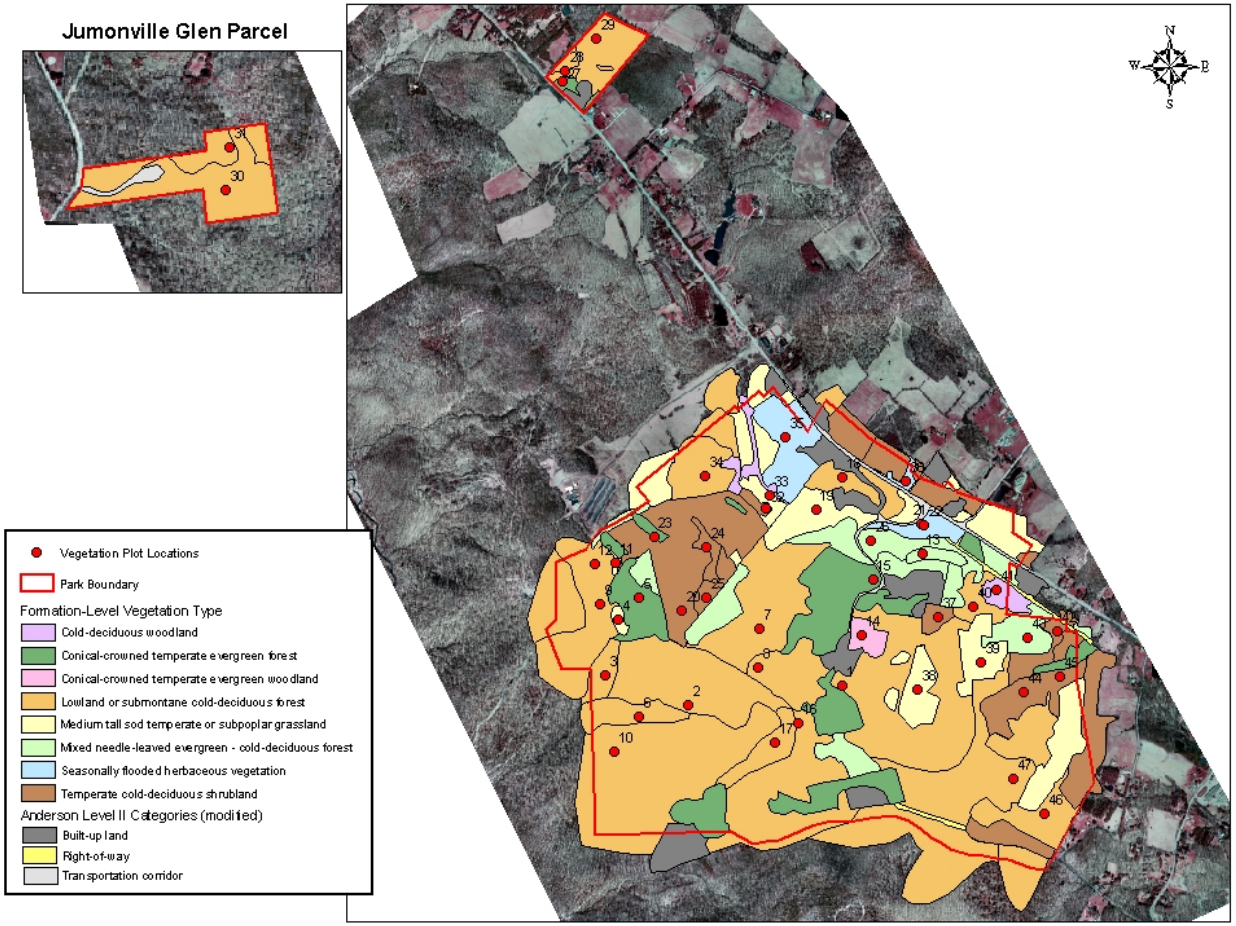

Figure 3. Locations of vegetation plots sampled in Fort Necessity National Battlefield for vegetation classification and mapping.

The vegetation plot data were analyzed using several multivariate statistical techniques available in the PC-ORD software. Different techniques were employed to provide multiple lines of evidence from which to interpret the results. For a detailed discussion of the statistical techniques used in this study, please refer to McCune and Grace (2002). To classify the plot data into vegetation associations, a two-way indicator species analysis (TWINSPAN) was performed using the percent cover of species data. TWINSPAN successively divides the plots into groups that are similar in species composition (Hill and Gauch 1979). A non-metric multidimensional ordination analysis (NMS) was also performed using both the percent cover of species and the environmental variables from the plots. NMS is an ordination technique well suited to non-normal data sets (Kruskgal and Wish 1978). In this analysis, Sorensen distance measure, a random starting configuration, and a stability criterion of 0.005 were employed. Forty runs were performed with the real data, with a maximum of 400 iterations. A multi-response permutation procedure (MRPP) was also performed on the plots' environmental variables to determine if the differences between the vegetation associations classified by the TWINSPAN and NMS were statistically significant. Sorensen distance measure was used in the MRPP.

Based on these analyses, park-specific local vegetation associations were identified and described in detail. These vegetation associations were then crosswalked to the National Vegetation Classification System (NVCS). The NVCS was developed by ecologists of the Natural Heritage Program network and The Nature Conservancy after many years of literature review, data collection, and data anlysis. This collaborative effort culminated in the publication of *International Classification of Ecological Communities: Terrestrial Vegetation of the United States* (Grossman et al. 1998). The International Classification of Ecological Communities, now known as the International Vegetation Classification, of which the NVCS is a subset, has been revised and refined since 1998, and is now managed by NatureServe in continued collaboration with the network of Natural Heritage Programs. The classification is housed in the Biotics database and is updated regularly. The upper levels of the NVCS were adopted as a standard by the Federal Geographic Data Committee to support the production of uniform statistics on vegetation at the national level (Federal Geographic Data Committee 1996). The Vegetation Mapping Program of the National Park Service adopted the alliance level, and where possible, the association level, as the mapping unit for national parks.

Based on the aforementioned analyses, the park-specific local vegetation associations were qualitatively compared to existing associations in the National Vegetation Classification System by searching for alliances sharing similar dominant species, as well as physiognomy and environmental setting. Total floristic composition was used to determine the appropriate association within the alliance. Global information on the associations from the NVCS was then appended to the local descriptions to provide resource managers with a broader context for the vegetation in the park.

Each vegetation association was assigned a common name based on the Terrestrial and Palustrine Plant Communities of Pennsylvania (Fike 1999). If no appropriate name existed in Fike (1999), the NVCS common name was used or a park-specific common name was created for successional and cultural vegetation types not easily handled by Fike (1999) or the NVCS.

A park-specific dichotomous key was also created for the vegetation associations to guide thematic accuracy assessment and for use by the park natural resource managers and others

(Appendix D). A dichotomous key is a tool for identifying unknown entities, in this case, vegetation associations. It is structured by a series of couplets, two statements that describe different, mutually exclusive characteristics of the associations. Choosing the statement that best fits the association in question leads the user to the correct association. The dichotomous key should be used in conjunction with the detailed vegetation association descriptions to confirm that the association selected with the key is appropriate.

Vegetation Map Preparation

Following the vegetation data analysis, the formation-level vegetation map was further edited and refined to develop an association-level vegetation map. Using ArcView 3.2, polygon boundaries were revised onscreen based on the plot data and additional field observations. Each polygon was assigned one of eight vegetation association types based on plot data, field observations, aerial photography signatures, and topographic maps. An aerial photograph interpretation key for the vegetation associations is located in Appendix A. However, several associations could not be distinguished reliably by aerial photography signatures alone. Plot data, field observations, and topographic maps were relied upon in these circumstances to inform the polygon delineation and association name assignments. After the vegetation association map was completed, the thematic accuracy of this map was assessed.

Accuracy Assessment

Two sources of potential error in the vegetation map include: 1) positional accuracy, in which a location on the photomosaic does not accurately align with the same location on the ground due to errors in orthorectification or triangulation; and 2) thematic accuracy, in which the vegetation type assigned to a particular location on the map does not correctly represent the vegetation at the same location in the park due to mapping error. The USGS/NPS Vegetation Mapping Program protocols (The Nature Conservancy 1994c) were followed to assess the positional and thematic accuracy of the Fort Necessity National Battlefield vegetation map.

Positional Accuracy Assessment

The horizontal positional accuracy of the mosaic was assessed using guidelines of the USGS/NPS Vegetation Mapping Program (The Nature Conservancy and Environmental Systems Research Institute 1994c). Well-defined positional accuracy ground control points, spaced throughout all quadrants of the mosaic, were placed on the final mosaic in ArcMap. Ground control points and zoomed-in screenshots of each point were plotted on hard copy maps with the mosaic as a background. These maps and plots were used to locate the ground control points in the field. For each plotted ground control point, field staff noted any alterations to the locations in the field, and then recorded the field coordinates with a Trimble Pro XR/XRS or GeoXT. Mapped ground control points that were physically inaccessible were also noted. The field crew correctly located and collected accuracy assessment data at 50 ground control points. The coordinate data were collected with real time GPS and post processed with differential correction using Pathfinder Office software. Prior to calculating accuracy, one ground control point, identified as an outlier with SAS's JMP program, was removed. For each of the remaining 49 points, the field-collected "true" or "reference" GPS coordinates were compared to the coordinates obtained from the mosaic viewed in ArcMap. Both pairs of coordinates for each

point were entered into a spreadsheet in order to calculate horizontal accuracy (in meters). Figure 4 shows the distribution of these 49 ground control points within the park and surrounding area.

Thematic Accuracy Assessment

The thematic accuracy of the vegetation map was assessed by the Pennsylvania Natural Heritage Program. A stratified random sampling approach was used, distributing the sampling effort across the eight vegetation associations. The number of samples per association varied according to the rarity of the vegetation type, both in terms of number of polygons and polygon size. Table 3 shows the number of accuracy assessment points recommended by the USGS/NPS Vegetation Mapping Program Protocol and the actual allocation of accuracy assessment points among the vegetation types. The number of sampling points was reduced from that recommended by the protocol for relatively abundant vegetation types and those type that are reliably delineated from the aerial photography, such as conifer plantations, modified successional forest, and successional old fields.

In order to randomly determine the location of these sampling points in the polygons, the random number generator function in Microsoft Excel was used to create 900 sets of random x and y coordinates that fell within the boundaries of the three units of Fort Necessity National Battlefield. These coordinates were imported into ArcView 3.2 and overlaid onto the vegetation map. The first coordinate listed in the table of coordinates to fall within a polygon, at least 50 m (164 ft) from the polygon boundary, was selected. All other points that fell within that polygon were then deleted. This procedure was carried out until all points were assigned (Figure 5).

Each accuracy assessment point was then located in the field using a Trimble Geo XM GPS unit during June 2004. The vegetation association at that location was then determined using the dichotomous key and the detailed vegetation descriptions. The minimum area of observation around the sampling point was a circle with a radius of 50 m (164 ft). The accuracy assessment data form used in this study is shown in Appendix E. Data from the 63 accuracy assessment points were then entered into the NatureServe PLOTS 2.0 Database System on a Microsoft Access platform during the fall of 2004. In the PLOTS 2.0 database, species were assigned standardized codes based on the PLANTS Database, Version 3.5, developed by the Natural Resource Conservation Service in cooperation with the Biota of North America Program (United States Department of Agriculture, National Resources Conservation Service 2004). For this report, some common names listed in the PLANTS Database were changed to reflect the common names typically used by ecologists and resource managers in this region. In addtion, the scientific name *Actaea racemosa* is used in this report instead of *Cimicifuga racemosa* in order to maintain consistency with the National Vegetation Classificatin System. The common and scientific names of plants observed during the thematic accuracy assessment sampling are listed in Appendix C. Some tree and shrub seedlings and immature herbaceous plants could only be identified to the genus level and are therefore listed in the appendix as such.

The thematic accuracy was then tabulated using a contingency matrix that compared the mapped vegetation associations with the actual vegetation associations observed in the field. Overall percent accuracy and the Kappa index were calculated (The Nature Conservancy and

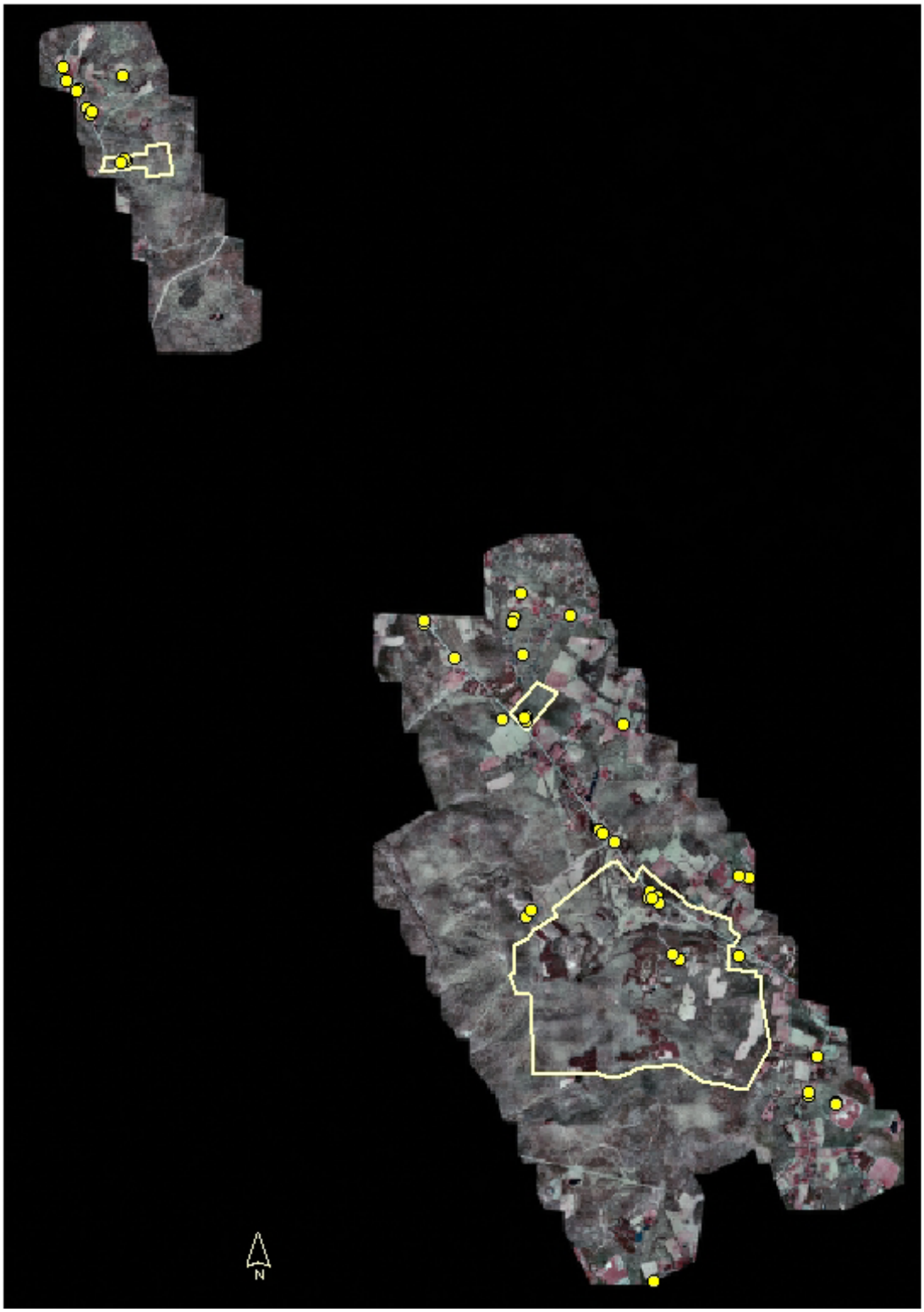

Figure 4. Ground control points (n=49) used to calculate horizontal positional accuracy of the Fort Necessity National Battlefield mosaic.

Table 3. Thematic accuracy assessment (AA) sampling strategy for Fort Necessity National Battlefield.

Vegetation Association	Number of Mapped Polygons	Mapped Hectares within Park Boundary	Number of AA Points Reccomended by Protocol[1]	Number of AA Points Sampled
Conifer Plantation	16	53.1	20	10
Northern Red Oak – Mixed Hardwood Forest	6	73.0	20	10
Red Maple – Black Cherry Successional Forest	15	50.3	20	10
Successional Old Field	16	64.1	20	10
Sugar Maple – Basswood Forest	1	0.3	1	1
Tuliptree Forest	13	56.0	20	10
Wet Meadow	9	16.4	5	5
White Oak – Mixed Hardwood Forest	7	42.9	20	7
Total	98	373.0	126	63

[1] The Nature Conservancy and Environmental Systems Research Institute. 1994 (c). NBS/NPS Vegetation Mapping Program: Accuracy Assessment Procedures. 71pp. Report to the National Biological Survey and the National Park Service. Arlington, VA and Redlands, CA. http://biology.usgs.gov/npsveg/standards.html. Last accessed 17 March 2005.

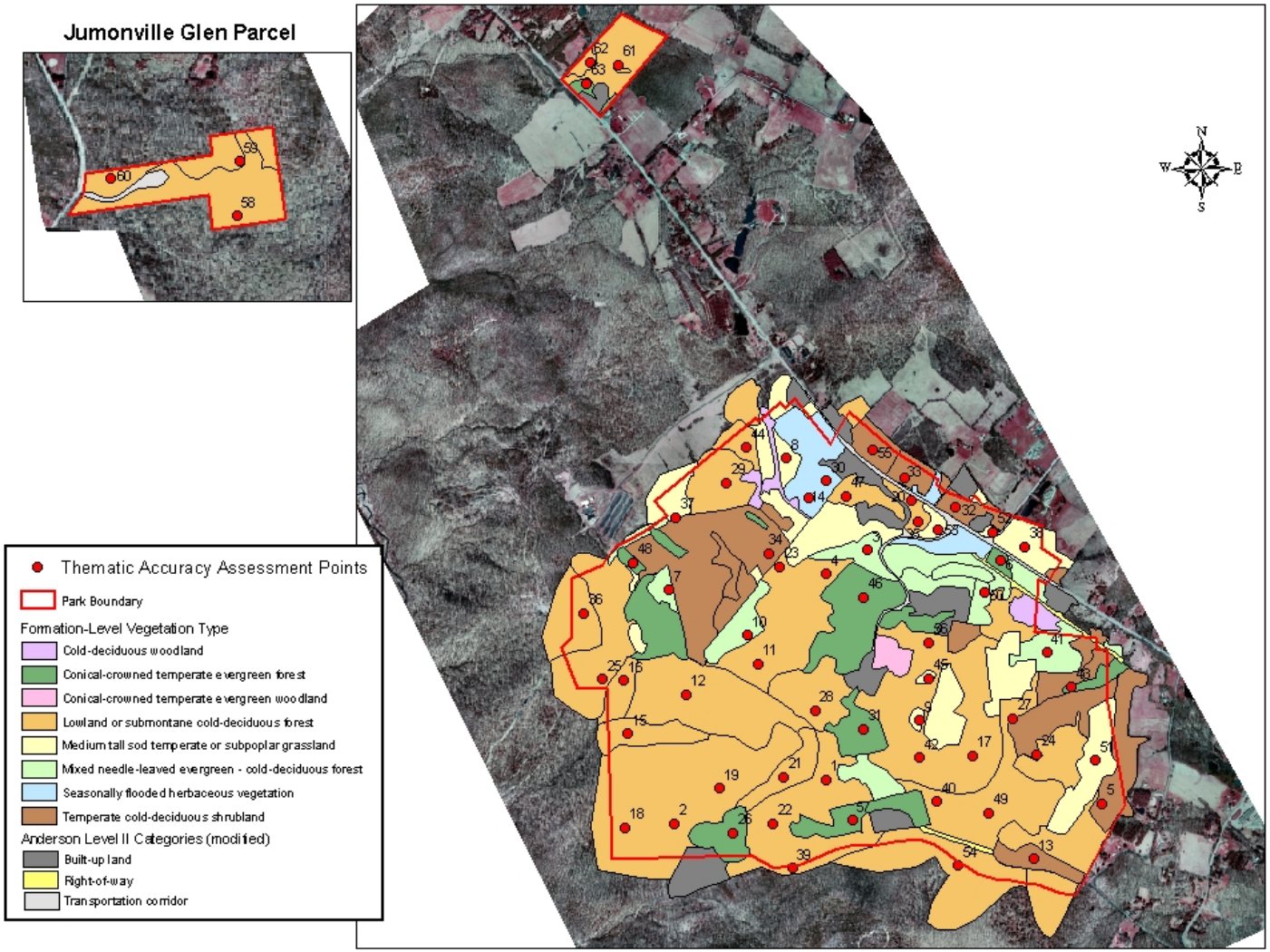

Figure 5. Locations of thematic accuracy assessment sampling points in Fort Necessity National Battlefield.

Environmental Systems Research Institute 1994c). Overall percent accuracy was calculated by dividing the number of correctly classified accuracy assessment points by the total number of accuracy assessment points. The Kappa index is the preferred method of reporting overall thematic accuracy because it takes into account that a certain number of correct classifications will occur by chance (Foody 1992).

Errors of omission and errors of commission were also calculated for each vegetation association. Both of these errors were calculated by dividing the number of correctly classified points in one association by the total number of points sampled in that association. Errors of omission indicate the probability that an accuracy assessment point classification will be correct and are calculated by mapped vegetation type. Errors of commission indicate the probability that a mapped vegetation type actually represents the vegetation on the ground. This error is calculated by observed vegetation type (The Nature Conservancy and Environmental Systems Research Institute 1994c).

Results

Vegetation Classification and Characterization

The vegetation asociations of Fort Necessity National Battlefield were classified using TWINSPAN and NMS analyses. A dendrogram of the TWINSPAN results is shown in Figure 6. Two associations, Tuliptree Forest and Conifer Plantation, that include wide variations in species composition did not group well in this analysis. The NMS analysis recommended a two-dimensional ordination (Figure 7). For each axis, p=0.0196 in which p is equal to the proportion of randomized runs in which the stress is less than or equal to the observed stress. Stress in NMS analysis is calculated based on the distances between data points in the ordination space as compared to the same distances in higher-dimensionality space (McCune and Grace 2002). The cumulative r^2 for the two axes was 0.619. Table 4 lists several environmental and physiognomic variables that showed strong correlations with the axes. Much stronger correlations were observed between the variables and axis 1 than between the variables and axis 2. As would be expected from these correlations, a low-lying herbaceous-dominated community falls on the extreme left-hand side of the ordination diagram and the higher elevation forest communities fall on the extreme right-hand side of the diagram (Figure 7). As in the TWINSPAN, the Tuliptree Forest and Conifer Plantation associations did not group consistently in the NMS analysis due to variation in species composition. For example, plots that were located in Conifer Plantation association that had undergone relatively recent silvicultural operations grouped with plots sampled in Red Maple – Black Cherry Successional Forest stands due to the similarity in weedy, adventitious hardwood understory and canopy trees.

Based on these analyses of multiple lines of evidence, it was determined that the vegetation at Fort Necessity National Battlefield can be described by eight vegetation associations: Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, Sugar Maple – Basswood Forest, Tuliptree Forest, Red Maple – Black Cherry Successional Forest, Conifer Plantation, Successional Old Field, and Wet Meadow. The MRPP indicated that the differences between these eight groups were statistically significant (p=0.01, A=0.07, T=-2.77).

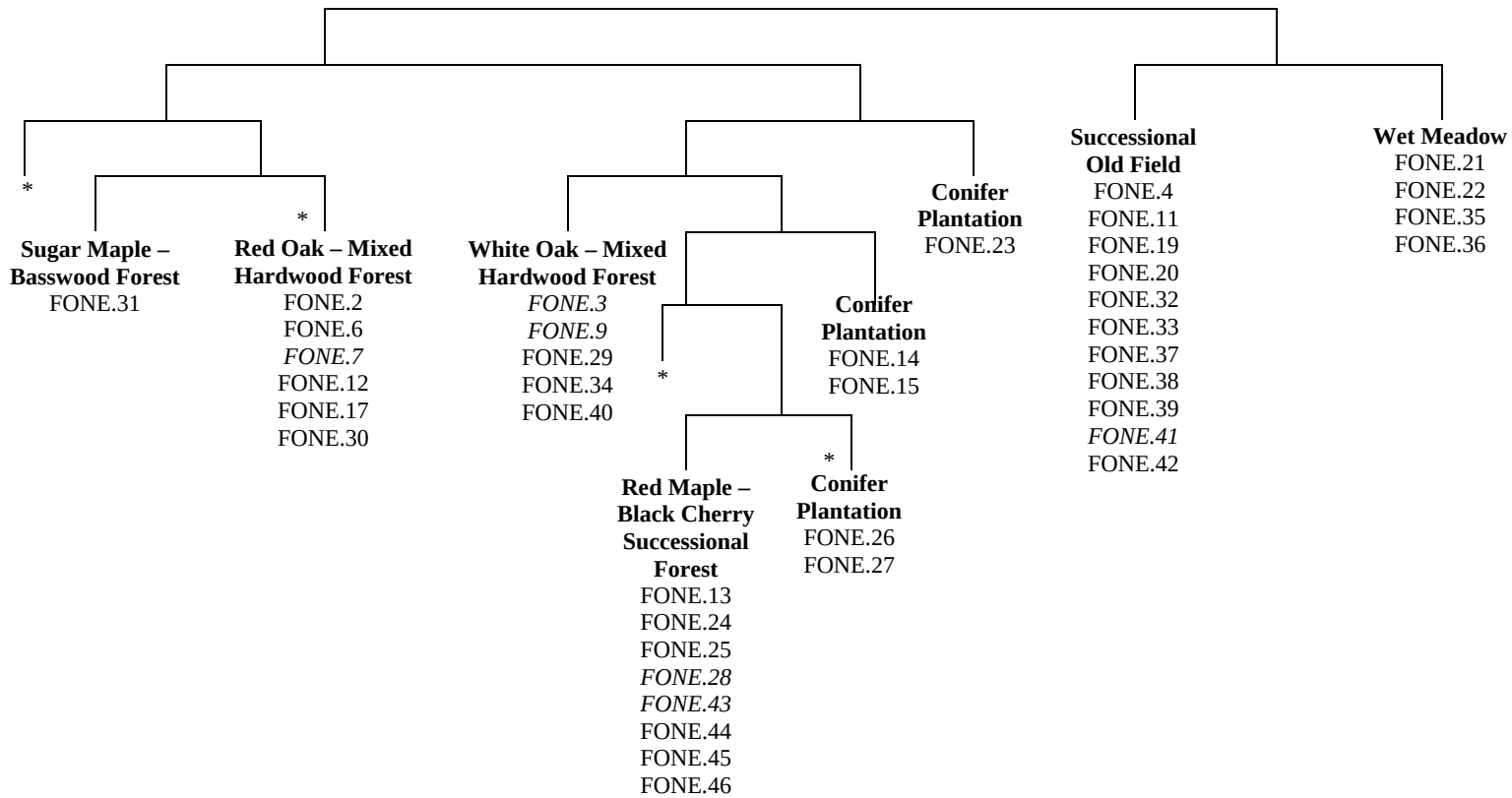

Figure 6. Dendrogram of the two-way indicator species analysis (TWINSPAN) results showing seven vegetation associations. The plots that were misclassified by the analysis are labeled in italics and are shown correctly classified. Due to variable species composition, the plots from Tuliptree Forest did not group consistently and are therefore not shown in this diagram. The branches of the dendrogram that originally contained the incorrectly classified Tuliptree Forest plots (FONE.1, FONE.8, FONE.10, FONE.16, FONE.18, and FONE.47) are marked with an asterisk (*).

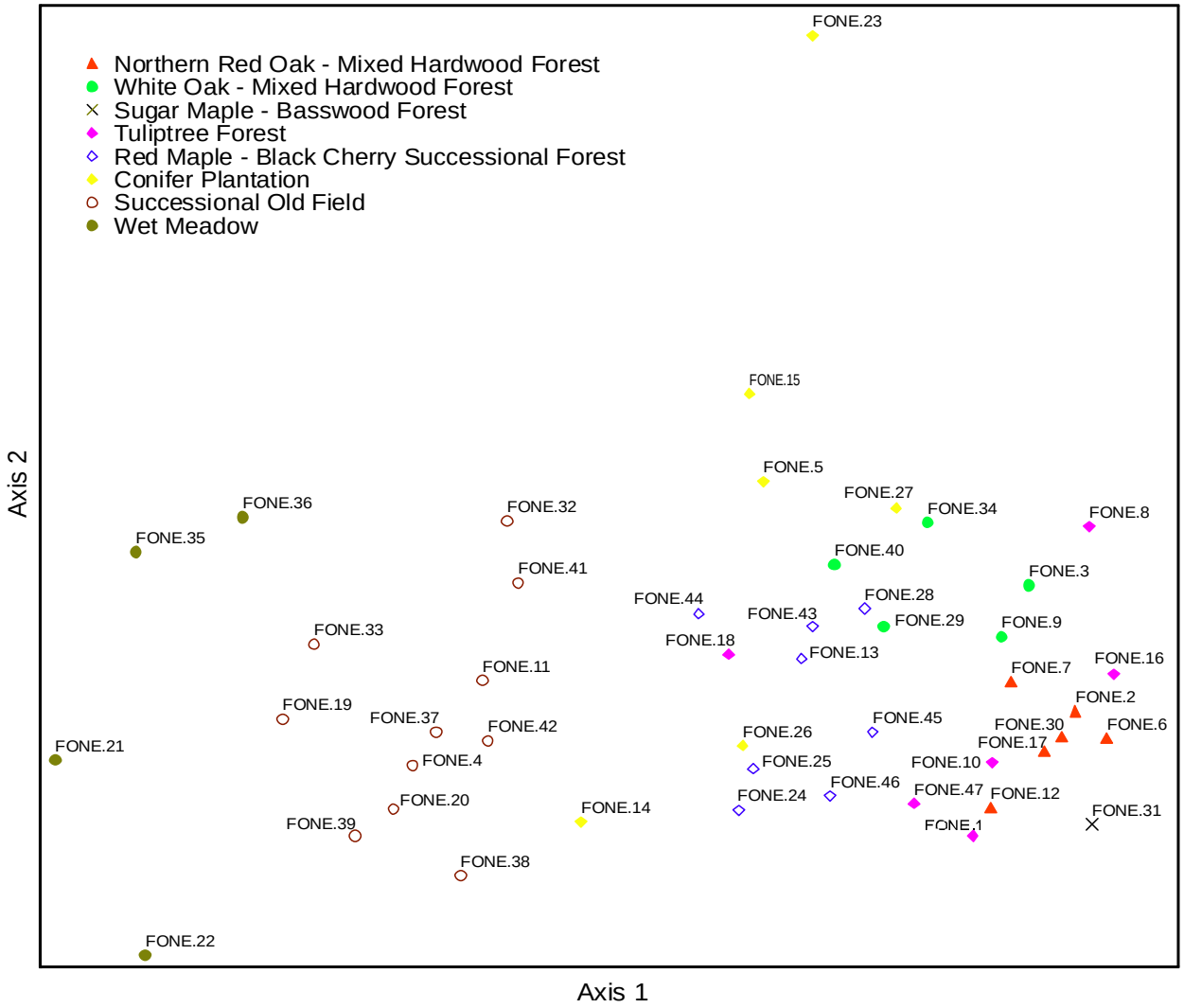

Figure 7. Ordination diagram from the non-metric multidimensional ordination analysis (NMS) showing eight vegetation associations.

Table 4. Correlations (r values) between measured variables and the two axes calculated in the non-metric multidimensional ordination analysis (NMS).

Measured Variable	Axis 1	Axis 2
Species Diversity	0.608	-0.173
Percent cover of emergent trees	0.641	-0.145
Percent cover of tree canopy	0.855	0.282
Percent cover of subcanopy	0.714	0.316
Percent cover of tall shrubs	0.545	0.053
Percent cover of herbaceous layer	-0.582	-0.391
Unvegetated Surface in Plot		
Percent cover of litter	0.681	0.412
Percent cover of wood	0.529	-0.213

Vegetation Association Descriptions

Detailed local descriptions for eight vegetation associations were written based on the plot data, photographs of each plot, and the ecologists' field experiences at Fort Necessity National Battlefield. These vegetation associations were then crosswalked to the National Vegetation Classification System (NVCS) by NatureServe ecologists. Detailed local and global descriptions of the vegetation associations follow. Representative photographs of each vegetation association are provided after each description. An index of these photos is located in Appendix F. A bibliography for the sources cited in the global vegetation descriptions from the NVCS is provided in Appendix G. A list of the plants found during the vegetation plot sampling and thematic accuracy assessment is located in Appendix C.

A dichotomous key was also developed for these eight vegetation associations (Appendix D). The dichotomous key should be used in conjunction with the detailed vegetation descriptions to confirm that the association selected with the key is appropriate. This key and the detailed vegetation descriptions were used in the thematic accuracy assessment and may be used by park resource managers and others to identify vegetation associations in the park.

Common Name (Park-specific): White Oak – Mixed Hardwood Forest

SYNONYMS

NVC English Name:	**(White Oak, Northern Red Oak, Black Oak) / Flowering Dogwood / Mapleleaf Viburnum Forest**
NVC Scientific Name:	***Quercus (alba, rubra, velutina) / Cornus florida / Viburnum acerifolium* Forest**
NVC Identifier:	**CEGL006336**

LOCAL INFORMATION

Environmental Description: This forest type is typically found on upper slopes in Fort Necessity National Battlefield; however, it often contains small seeps and drainages.
Vegetation Description: White oak (*Quercus alba*) and northern red oak (*Quercus rubra*) are typically dominant as emergent trees and in the canopy layer, accompanied by common serviceberry (*Amelanchier arborea*), red maple (*Acer rubrum*) and black cherry (*Prunus serotina*) in the canopy and subcanopy layers. Other common canopy species include tuliptree (*Liriodendron tulipifera*), white ash (*Fraxinus americana*), and shagbark hickory (*Carya ovata*). Emergent trees stand 27–36m in height and can cover 25–70% of the forest, although some stands lack emergent trees. The canopy trees extend from 20 to 27 m in height and cover 50–80% of the area; while the subcanopy trees (8–15m in height) cover 30–60% of the stand. The tall shrub layer is moderately dense (40–70% cover) and contains red maple, black cherry, common serviceberry, cucumber-tree (*Magnolia acuminata*), American hornbeam (*Carpinus caroliniana*), northern spicebush (*Lindera benzoin*), hawthorns (*Crataegus* spp.), apples (*Malus* spp.) and several other common hardwood tree species. The short shrub layer can be sparse or dense (20–70% cover) and includes diverse shrubs and hardwood tree seedlings. Ericaceous species such as blueberries (*Vaccinium pallidum, V. angustifolium, V. stamineum*) and eastern teaberry (*Gaultheria procumbens*) are common and often diagnostic for this community on higher slopes. Other common species are bristly dewberry (*Rubus hispidus*) and black cherry, often accompanied by northern dewberry (*Rubus flagellaris*), hawthorns, common serviceberry, mapleleaf viburnum (*Viburnum acerifolium*), Japanese barberry (*Berberis thunbergii*) and Morrow's honeysuckle (*Lonicera morrowii*). The herbaceous layer is sparse (20–60% cover) with low diversity. New York fern (*Thelypteris noveboracensis*) is the most common herbaceous species along with bearded shorthusk (*Brachyelytrum erectum*), fan clubmoss (*Lycopodium digitatum*), partridgeberry (*Mitchella repens*), common cinquefoil (*Potentilla simplex*), deertongue (*Dichanthelium clandestinum*), slender woodland sedge (*Carex digitalis*) and sessileleaf bellwort (*Uvularia sessilifolia*). Many other fern species are present throughout this type including eastern hayscented fern (*Dennstaedtia punctilobula*), Christmas fern (*Polystichum acrostichoides*), intermediate woodfern (*Dryopteris intermedia*) on dry sites and interrupted fern (*Osmunda claytonia*), cinnamon fern (*Osmunda cinnamomea*), and sensitive fern (*Onoclea sensibilis*) in more mesic areas. Natural seeps and drainages that occur in small patches throughout this community contribute to the presence of hydrophilic species in the understory in these areas. In one area, near FONE.34, the White Oak – Mixed Hardwood Forest also houses many vernal pools. Vines such as eastern poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax glauca, S. rotundifolia*), grape (*Vitis* spp.), and Virginia creeper (*Parthenocissus quinquefolia*) can cover up to 25% of this forest type.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Quercus alba, Quercus rubra, Acer rubrum, Prunus serotina*
Tree subcanopy	Broad-leaved deciduous tree	*Amelanchier arborea, Quercus alba, Quercus rubra, Acer rubrum, Prunus serotina*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Magnolia acuminata, Carpinus caroliniana, Lindera benzoin, Crataegus* spp., *Acer rubrum, Prunus serotina*
Short shrub/sapling	Broad-leaved deciduous shrub	*Rubus hispidus, Rubus flagellaris, Vaccinium* spp.
Herb (field)	Forb	*Thelypteris noveboracensis, Polystichum acrostichoides, Mitchella repens, Dennstaedtia punctilobula*
Herb (field)	Graminoid	*Brachyelytrum erectum, Panicum clandestinum*
Vine	Vine	*Vitis* spp., *Smilax rotundifolia*

Characteristic Species: *Quercus alba, Quercus rubra, Amelanchier arborea, Vaccinium* spp., *Brachyelytrum erectum, Thelypteris noveboracensis*.
Other Noteworthy Species: Information not available.
Local Range: This common forest type is found throughout Fort Necessity National Battlefield.
Classification Comments: White Oak – Mixed Hardwood Forest is distinguished from other hardwood forest types by the abundance of *Quercus alba, Quercus rubra,*and *Acer rubrum* in the canopy, often with *Vaccinium* spp. in the groundstory.
Other Comments: None.
Local Description Authors: S. J. Perles (PNHP).
Plots: FONE.3, FONE.9, FONE.29, FONE.34, FONE.40.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Forest (I)
Physiognomic Subclass	Deciduous forest (I.B.)
Physiognomic Group	Cold-deciduous forest (I.B.2.)
Physiognomic Subgroup	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
Formation	Lowland or submontane cold-deciduous forest (I.B.2.N.a.)
Alliance	*Quercus alba - (Quercus rubra, Carya* spp.) Forest Alliance (A.239)
Alliance (English name)	White Oak - (Northern Red Oak, Hickory species) Forest Alliance
Association	*Quercus (alba, rubra, velutina) / Cornus florida / Viburnum acerifolium* Forest
Association (English name)	(White Oak, Northern Red Oak, Black Oak) / Flowering Dogwood / Mapleleaf Viburnum Forest
Association (Common name)	Northeastern Dry Oak-Hickory Forest

Ecological System(s): Northern Atlantic Coastal Plain Dry Hardwood Forest (CES203.475)
Northeastern Interior Dry-Mesic Oak Forest (CES202.592)

GLOBAL DESCRIPTION

Concept Summary: This northeastern oak-hickory forest occurs on well-drained loamy sand of midslopes. This vegetation is ecologically transitional between dry-rich oak-hickory forests of relatively high diversity and dry, acidic oak-species-poor forests. *Quercus rubra, Quercus alba* and *Quercus velutina* are prominent in the canopy. *Quercus prinus* and *Quercus coccinea* are canopy associates in the southern portion of the range. Typical hickory species include *Carya glabra, Carya ovata, Carya alba*, and *Carya ovalis*. Other canopy associates may include *Acer rubrum, Sassafras albidum,* and *Amelanchier arborea*. At the northern range limit of this type, *Pinus strobus* and *Betula lenta* also occur as minor associates. *Cornus florida* is a characteristic understory tree in portions of the range. The shrub layer is characterized by *Viburnum acerifolium*, with other frequent associates including *Hamamelis virginiana, Vaccinium corymbosum, Corylus cornuta*, and *Corylus americana*. A dwarf-shrub layer may be common, but generally not abundant, characterized by *Vaccinium pallidum* and *Gaylussacia baccata*, with *Vaccinium angustifolium* occurring more frequently to the north. The herbaceous layer is characterized by *Carex pensylvanica, Maianthemum racemosum* ssp. *racemosum, Aralia nudicaulis, Hieracium venosum, Solidago bicolor, Desmodium glutinosum, Desmodium paniculatum, Melampyrum lineare, Chimaphila maculata, Eurybia divaricata, Danthonia spicata, Aureolaria* spp., and *Helianthemum canadense*.

Environmental Description: This forest type occurs on well-drained loamy sand of midslopes.

Vegetation Description: This vegetation is ecologically transitional between dry-rich oak-hickory forests of relatively high diversity and dry, acidic oak-species-poor forests. *Quercus rubra, Quercus alba* and *Quercus velutina* are prominent in the canopy Typical hickory species include *Carya glabra, Carya ovata, Carya alba*, and *Carya ovalis*. Other canopy associates may include *Acer rubrum, Sassafras albidum,* and *Amelanchier arborea*. At the northern range limit of this type, *Pinus strobus* and *Betula lenta* also occur as minor associates. *Cornus florida* is a characteristic understory tree in portions of the range. The shrub layer is characterized by *Viburnum acerifolium*, with other frequent associates including *Hamamelis virginiana, Vaccinium corymbosum, Corylus cornuta*, and *Corylus americana*. A dwarf-shrub layer may be common, but generally not abundant, characterized by *Vaccinium pallidum* and *Gaylussacia baccata*, with *Vaccinium angustifolium* occurring more frequently to the north. The herbaceous layer is characterized by *Carex pensylvanica, Maianthemum racemosum* ssp. *racemosum, Aralia nudicaulis, Hieracium venosum, Solidago bicolor, Desmodium glutinosum, Desmodium paniculatum, Melampyrum lineare, Chimaphila maculata, Eurybia divaricata, Danthonia spicata, Aureolaria* spp., and *Helianthemum canadense*.

Most Abundant Species: Information not available.

Characteristic Species: Information not available.

Other Noteworthy Species: Information not available.

USFWS Wetland System: None.

DISTRIBUTION

Range: This association occurs from Maine to Virginia.

States/Provinces: CT, DE:S3?, MA, MD, ME, NH, NJ:S4S5, NY:S3, PA, RI, VA, VT.

Federal Lands: NPS (Booker T. Washington, Cape Cod, Fort Necessity, Fredericksburg-Spotsylvania, Morristown, Prince William?).

CONSERVATION STATUS

Rank: G4G5 (24-Jan-2005).

Reasons: This type is not naturally rare and has a wide geographic distribution. Mature stands, however, are uncommon and most stands are subject to logging disturbances or even complete destruction if located in rapidly developing suburban areas.

CLASSIFICATION INFORMATION

Status: Standard.

Confidence: 2 – Moderate.

Comments: None.

Similar Associations:

Acer saccharum - Betula alleghaniensis - Quercus rubra / Viburnum acerifolium Forest (CEGL006943)

Carya (glabra, ovata) - Fraxinus americana - Quercus spp. Forest (CEGL006236)

Quercus alba - Quercus (rubra, coccinea) - Carya (alba, glabra) / Vaccinium pallidum Piedmont Dry-Mesic Forest (CEGL008475)--is more diverse and occupies soils with slightly higher base status. *Quercus velutina* is not as characteristic of this type. A number of southern herbs such as *Aristolochia serpentaria* are not found in CEGL006375.

Quercus alba - Quercus rubra - Carya (alba, ovata) / Cornus florida Acid Forest (CEGL002067)--also contains *Actaea racemosa* and can occur on cherty limestone, and *Quercus velutina* is not characteristic.

Quercus coccinea - Quercus velutina / Sassafras albidum / Vaccinium pallidum Forest (CEGL006375)--lacks *Viburnum acerifolium* and *Cornus florida* and in general is less diverse and occurring on relatively more nutrient-poor soils.

Quercus velutina - Quercus alba - Carya (glabra, ovata) Forest (CEGL002076)--also contains *Quercus ellipsoidalis* or *Quercus macrocarpa* and is of shorter stature and more open canopy.

Quercus velutina / Carex pensylvanica Forest (CEGL002078)--is drier and more infertile, and lacks *Viburnum acerifolium, Hamamelis virginiana* and other shrubs.

Related Concepts:

Quercus montana - Quercus rubra - Carya (ovalis, glabra) / Viburnum acerifolium Forest (Fleming pers. comm.) ?

Mesic Coastal Plain mixed oak forest (Breden 1989) ?

Northeastern Acidic Oak-Hickory Forest (Fleming et al. 2004) ? SNE mesic central hardwood forest on acidic till (Rawinski 1984) ?

SOURCES

Description Authors: S. L. Neid and L. A. Sneddon.

References: Berdine 1998, Breden 1989, Breden et al. 2001, Clancy 1996, Damman 1977, Eastern Ecology Working Group n.d., Edinger et al. 2002, Enser 1999, Fike 1999, Fleming et al. 2001, Fleming pers. comm., Gawler 2002, Hunt 1997, MENHP 1991, McCoy and Fleming 2000, Metzler and Barrett 2001, Patterson pers. comm., Rawinski 1984, Sperduto 1997b, Swain and Kearsley 2001.

Figure 8. White Oak – Mixed Hardwood Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.3). July 2003. NAD 1983 / UTM easting 619871, northing 4407505.

Figure 9. White Oak – Mixed Hardwood Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.34). August 2003. NAD 1983 / UTM easting 620310, northing 4408384.

Common Name (Park-specific): Northern Red Oak – Mixed Hardwood Forest

SYNONYMS
NVC English Name: **Northern Red Oak - Sugar Maple - Tuliptree Forest**
NVC Scientific Name: ***Quercus rubra - Acer saccharum - Liriodendron tulipifera* Forest**
NVC Identifier: **CEGL006125**

LOCAL INFORMATION

Environmental Description: This forest type is found on mid to lower slopes in Fort Necessity National Battlefield, typically on well-drained soils.
Vegetation Description: The diagnostic canopy composition for this type is: northern red oak (*Quercus rubra*) in the emergent and canopy layers, red maple (*Acer rubrum*) in the canopy and subcanopy layers, and cucumber-tree (*Magnolia acuminata*) in the subcanopy. However, several other species, such as pignut hickory (*Carya glabra*), chestnut oak (*Quercus prinus*), white oak (*Quercus alba*), black oak (*Quercus velutina*), tuliptree (*Liriodendron tulipifera*), white ash (*Fraxinus americana*), and sugar maple (*Acer saccharum*), can be codominant in any of the canopy layers. Black oak and chestnut oak are found only on the most well-drained sites within this community type (i.e. ridges and well-drained upper slopes). Natural seeps that occur in small patches throughout this community contribute to the presence of mesophytic trees. The emergent trees stand 27–36m in height and cover 30–50% of the stand. The canopy trees extend from 20 to 30 m in height and cover 45–75% of the area; while the subcanopy trees (10–20m in height) cover 30–60% of the stand. The tall shrub layer can be sparse or dense (25–80% cover) and contains hophornbeam (*Ostrya virginiana*), cucumber-tree , common serviceberry (*Amelanchier arborea*), American chestnut (*Castanea dentata*), mountain laurel (*Kalmia latifolia*), American hornbeam (*Carpinus caroliniana*), sweet birch (*Betula lenta*), chokecherry (*Prunus virginiana*), and several species found in the canopy layers. Similar species are found in the relatively sparse short shrub layer (10–45% cover), including: hophornbeam, common serviceberry, American chestnut, black cherry (*Prunus serotina*), Blue Ridge blueberry (*Vaccinium pallidum*), northern spicebush (*Lindera benzoin*) and a variety of hardwood tree seedlings. The herbaceous layer is sparse with low diversity and is relatively uniform throughout. The most prevalent species include eastern hayscented fern (*Dennstaedtia punctilobula*), New York fern (*Thelypteris noveboracensis*), intermediate woodfern (*Dryopteris intermedia*) roundleaf yellow violet (*Viola rotundifolia*), white snakeroot (*Ageratina altissima* var. *altissima*), common cinquefoil (*Potentilla simplex*), American squawroot (*Conopholis americana*), yellow fairybells (*Disporum lanuginosum*), Christmas fern (*Polystichum acrostichoides*), slender woodland sedge (*Carex digitalis*) and black bugbane (*Actaea racemosa*). Vine species such as eastern poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax glauca, S. rotundifolia*), grape (*Vitis* spp.), and Virginia creeper (*Parthenocissus quinquefolia*) cover to up 30% of this forest type.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Quercus rubra, Acer rubrum*
Tree subcanopy	Broad-leaved deciduous tree	*Acer rubrum, Magnolia acuminata*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Ostrya virginiana, Magnolia acuminata, Amelanchier arborea*
Short shrub/sapling	Broad-leaved deciduous shrub	*Ostrya virginiana, Amelanchier arborea, Castanea dentata*
Herb (field)	Forb	*Dennstaedtia punctilobula, Thelypteris noveboracensis, Dryopteris intermedia, Ageratina altissima* var. *altissima, Potentilla simplex*
Vine	Vine	*Smilax rotundifolia, Vitis* spp.

Characteristic Species: *Quercus rubra, Acer rubrum, Magnolia acuminata, Castanea dentata, Dennstaedtia punctilobula, Thelypteris noveboracensis.*
Other Noteworthy Species: Information not available.
Local Range: This common forest type is found throughout Fort Necessity National Battlefield.
Classification Comments: Northern Red Oak – Mixed Hardwood Forest can be distinguished from other hardwood forest types by the prominence of *Quercus rubra, Acer rubrum,* and *Magnolia acuminata* in the canopy and subcanopy.
Other Comments: None.
Local Description Authors: S. J. Perles (PNHP).
Plots: FONE.2, FONE.6, FONE.7, FONE.12, FONE.17, FONE.30.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Forest (I)
Physiognomic Subclass	Deciduous forest (I.B.)
Physiognomic Group	Cold-deciduous forest (I.B.2.)
Physiognomic Subgroup	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
Formation	Lowland or submontane cold-deciduous forest (I.B.2.N.a.)
Alliance	*Quercus rubra - (Acer saccharum)* Forest Alliance (A.251)
Alliance (English name)	Northern Red Oak - (Sugar Maple) Forest Alliance
Association	*Quercus rubra - Acer saccharum - Liriodendron tulipifera* Forest
Association (English name)	Northern Red Oak - Sugar Maple - Tuliptree Forest
Association (Common name)	High Allegheny Rich Red Oak - Sugar Maple Forest
Ecological System(s):	Laurentian-Acadian Pine-Hemlock-Hardwood Forest (CES201.563) Appalachian (Hemlock)-Northern Hardwood Forest (CES202.593)

GLOBAL DESCRIPTION

Concept Summary: This northern red oak - sugar maple community is found primarily in the Allegheny Plateau and Appalachian Mountain regions of the United States, as well as on the northern Piedmont north to the Hudson Valley, with possible extensions east and west of those areas. It is typically found in coves, on moist north- and east-facing slopes and on well-drained

flats. Soils are slightly acidic and of intermediate fertility. Stands contain a closed-canopy tree layer. *Acer saccharum, Liriodendron tulipifera, Quercus alba*, and *Quercus rubra* are the leading dominant or characteristic species. *Acer rubrum, Carya ovata, Carya alba, Carya glabra, Nyssa sylvatica, Quercus coccinea, Quercus prinus*, and *Quercus velutina* are possible associates. A wide variety of more mesic associates, such as *Betula alleghaniensis, Betula lenta, Fagus grandifolia, Magnolia acuminata*, and *Fraxinus americana*, occur in some areas. In addition to *Acer saccharum* reproduction, some understory species may include *Carpinus caroliniana, Cercis canadensis*, and *Ostrya virginiana*. Shrub and vine species include *Amelanchier laevis, Amelanchier arborea, Cornus* spp., *Hamamelis virginiana, Lindera benzoin, Viburnum acerifolium, Viburnum dentatum* var. *lucidum*, and *Vitis riparia*. Ericaceous shrubs, such as *Kalmia latifolia, Vaccinium angustifolium* and *Vaccinium pallidum*, may also be present. The ground layer species are highly variable but include *Caulophyllum thalictroides, Ageratina altissima, Dennstaedtia punctilobula, Podophyllum peltatum, Maianthemum racemosum* ssp. *racemosum, Medeola virginiana, Thelypteris noveboracensis, Dryopteris marginalis, Actaea* spp., and *Uvularia sessilifolia*.

Environmental Description: Stands are typically found in coves, on moist north- and east-facing slopes, and on well-drained flats. Soils are slightly acid and of intermediate fertility (Anderson 1982, Reschke 1990, Fike 1999).

Vegetation Description: Stands of this northern red oak - sugar maple forest contain a closed-canopy tree layer. *Acer saccharum, Liriodendron tulipifera, Quercus alba*, and *Quercus rubra* are the leading dominants. *Acer rubrum, Carya ovata, Carya alba, Nyssa sylvatica, Quercus coccinea, Quercus prinus*, and *Quercus velutina* are possible associates. *Liriodendron* dominance may indicate a past disturbance history, and *Carya* spp. may share dominance in some stands. There is evidence (Fleming 1999) that *Castanea dentata* may have been important in these stands prior to its demise. A wide variety of more mesic associates, such as *Betula alleghaniensis, Betula lenta, Fagus grandifolia*, and *Fraxinus americana*, could occur but are negligible in dominance. In addition to *Acer saccharum* reproduction, some understory species may include *Carpinus caroliniana, Cercis canadensis*, and *Ostrya virginiana*. Shrub and vine species include *Amelanchier laevis, Amelanchier arborea, Cornus* spp., *Hamamelis virginiana, Lindera benzoin, Viburnum acerifolium, Viburnum dentatum* var. *lucidum*, and *Vitis riparia*. Ericaceous shrubs, such as *Kalmia latifolia, Vaccinium angustifolium* and *Vaccinium pallidum*, may also be present. The ground layer species are highly variable but include *Caulophyllum thalictroides, Dennstaedtia punctilobula, Podophyllum peltatum, Maianthemum racemosum* ssp. *racemosum, Medeola virginiana, Thelypteris noveboracensis*, and *Uvularia sessilifolia*.

Most Abundant Species: Information not available.

Characteristic Species: Information not available.

Other Noteworthy Species: Information not available.

USFWS Wetland System: None.

DISTRIBUTION

Range: This red oak - sugar maple community is found primarily in the Allegheny Plateau and Appalachian Mountain regions of the United States, with possible extensions east and west of those areas, ranging from southeastern New York and New Jersey, and west to Pennsylvania, West Virginia, and southeast Ohio.

States/Provinces: CT, NJ, NY, OH, PA, WV?

Federal Lands: NPS (Fort Necessity).

CONSERVATION STATUS
Rank: GNR (31-Dec-1997).
Reasons: Information not available.

CLASSIFICATION INFORMATION
Status: Standard.
Confidence: 2 – Moderate.
Comments: According to Anderson (1982) in Ohio, where this community is found in the southeastern unglaciated plateau region, it is differentiated from the oak-maple type, ~*Quercus alba - Quercus rubra - Quercus prinus - Acer saccharum / Lindera benzoin* Forest (CEGL002059)$$, and the Appalachian oak forest type, ~*Quercus prinus - Quercus (alba, coccinea, velutina) / Viburnum acerifolium - (Kalmia latifolia)* Forest (CEGL005023)$$, by the substantial presence (over 20% canopy or basal area) of *Liriodendron tulipifera* and insignificant amounts of *Fagus grandifolia* or other mesic tree species. This type concept may overlap considerably with that of the oak-maple type, ~*Quercus alba - Quercus rubra - Quercus prinus - Acer saccharum / Lindera benzoin* Forest (CEGL002059). Braun (1950, e.g., p. 140) reports stands similar to this type in the Shawnee Hills and Mammoth Cave area of Kentucky, as well as other Interior Low Plateau sites. In New York, this type is reported primarily from the southeastern part of the State (Reschke 1990).
Similar Associations:
Acer saccharum - Quercus rubra - Carya (glabra, ovata) / Ageratina altissima - Bromus pubescens Forest (CEGL008517)--for similar vegetation in Virginia
Fagus grandifolia - Quercus alba - Quercus rubra Forest (CEGL006377)
Quercus alba - (Quercus rubra, Acer saccharum, Fagus grandifolia) / Aesculus flava Forest (CEGL007233)--is a related type to the south and west
Quercus alba - Quercus rubra - Quercus prinus - Acer saccharum / Lindera benzoin Forest (CEGL002059)
Quercus prinus - Quercus (alba, coccinea, velutina) / Viburnum acerifolium - (Kalmia latifolia) Forest (CEGL005023)
Quercus rubra - Acer saccharum - Tilia americana var. *heterophylla - Aesculus flava - (Cladrastis kentukea)* Forest (CEGL007698)
Quercus rubra - Tsuga canadensis - Liriodendron tulipifera / Hamamelis virginiana Forest (CEGL006566)
Related Concepts:
Dry-Mesic Inland Mixed Oak Forest, mixed oak-hardwood type (Breden 1989) ?

SOURCES
Description Authors: D. Faber-Langendoen.
References: Anderson 1982, Braun 1950, Breden 1989, Breden et al. 2001, Eastern Ecology Working Group n.d., Fike 1999, Fleming 1999, Lundgren 2001, Reschke 1990.

Figure 10. Northern Red Oak – Mixed Hardwood Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.6). July 2003. NAD 1983 / UTM easting 620017, northing 4407319.

Figure 11. Northern Red Oak – Mixed Hardwood Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.17). July 2003. NAD 1983 / UTM easting 620618, northing 4407207.

Common Name (Park-specific): Sugar Maple – Basswood Forest

SYNONYMS

NVC English Name:	**Sugar Maple - White Ash - American Basswood - Tuliptree / Black Cohosh Forest**
NVC Scientific Name:	***Acer saccharum - Fraxinus americana - Tilia americana - Liriodendron tulipifera / Actaea racemosa* Forest**
NVC Identifier:	**CEGL006237**

LOCAL INFORMATION

Environmental Description: This forest type is found only in the Jumonville Glen section of Fort Necessity National Battlefield. This flat low-lying area contains calcareous bedrock which influences the composition of the forest.

Vegetation Description: Basswood (*Tilia americana*) and sugar maple (*Acer saccharum*) dominate the canopy, with northern red oak (*Quercus rubra*), red maple (*Acer rubrum*) and cucumber-tree (*Magnolia acuminata*) also present. The canopy contains three layers: an emergent layer (33–38m in height) that covers approximately 25% of the stand; the canopy at an average of 25 m in height that covers 65% of the area; and a subcanopy (17m in height) that covers 15% of the stand. Northern spicebush (*Lindera benzoin*) dominates the dense tall shrub layer, along with American witchhazel (*Hamamelis virginiana*), common serviceberry (*Amelanchier arborea*), and American basswood. The dense short shrub layer has a similar species composition, with the additions of sweet birch (*Betula lenta*), sugar maple, and black cherry (*Prunus serotina*). The sparse herbaceous layer is dominated by eastern hayscented fern (*Dennstaedtia punctilobula*), New York fern (*Thelypteris noveboracensis*), cinnamon fern (*Osmunda cinnamomea*), intermediate woodfern (*Dryopteris intermedia*), spinulose woodfern (*Dryopteris carthusiana*), violets (*Viola* spp.), and Jack in the pulpit (*Arisaema triphyllum*). Vines such as roundleaf greenbriar (*Smilax rotundifolia*) and Virginia creeper (*Parthenocissus quinquefolia*) can cover up to 35% of the forest.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Tilia americana, Acer saccharum*
Tree subcanopy	Broad-leaved deciduous tree	*Tilia americana, Acer rubrum*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Lindera benzoin, Hamamelis virginiana*
Short shrub/sapling	Broad-leaved deciduous shrub	*Lindera benzoin*
Herb (field)	Forb	*Dennstaedtia punctilobula, Thelypteris noveboracensis*
Vine	Vine	*Smilax rotundifolia*

Characteristic Species: *Tilia americana, Acer saccharum, Quercus rubra, Magnolia acuminata*.

Other Noteworthy Species: Information not available.

Local Range: Within Fort Necessity National Battlefield, this forest type occurs only in the Jumonville Glen Unit, in a flat low-lying area that contains calcareous bedrock.

Classification Comments: Sugar Maple – Basswood Forest is distinguished from other hardwood forest types by the dominance of *Tilia americana, Acer saccharum*.

Other Comments: None.

Local Description Authors: S. J. Perles (PNHP).

Plots: FONE.31.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Forest (I)
Physiognomic Subclass	Deciduous forest (I.B.)
Physiognomic Group	Cold-deciduous forest (I.B.2.)
Physiognomic Subgroup	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
Formation	Lowland or submontane cold-deciduous forest (I.B.2.N.a.)
Alliance	*Acer saccharum* - *Fraxinus americana* - *Tilia americana* Forest Alliance (A.217)
Alliance (English name)	Sugar Maple - White Ash - American Basswood Forest Alliance
Association	*Acer saccharum* - *Fraxinus americana* - *Tilia americana* – *Liriodendron tulipifera / Actaea racemosa* Forest
Association (English name)	Sugar Maple - White Ash - American Basswood - Tuliptree / Black Cohosh Forest
Association (Common name)	Central Appalachian Rich Cove Forest
Ecological System(s):	Southern and Central Appalachian Cove Forest (CES202.373)

GLOBAL DESCRIPTION

Concept Summary: This is a rich mesic, deciduous forest of the High Alleghenies, Western Allegheny Plateau, and Central Appalachians south to the Cumberlands of eastern Kentucky. Stands occur in coves, slope bases, lower slopes, and moderate slopes. Soils are typically deep, fertile, moderately to well-drained and are often derived from calcareous parent materials, with textures including sands, loams, and silt loams. The canopy is dominated by *Acer saccharum* with *Fraxinus americana, Liriodendron tulipifera,* and *Tilia americana* being very characteristic. Associated canopy trees include *Quercus rubra, Ostrya virginiana, Ulmus rubra, Acer rubrum, Betula alleghaniensis, Betula lenta, Fagus grandifolia, Juglans nigra, Carya cordiformis,* and *Prunus serotina*. The shrub layer is of variable composition, characterized by *Cornus alternifolia, Hamamelis virginiana, Lindera benzoin, Asimina triloba, Lonicera canadensis, Rhododendron periclymenoides,* and *Viburnum acerifolium*. The herb layer is diverse and made up of *Adiantum pedatum, Asarum canadense, Actaea racemosa, Cardamine* spp., *Hepatica nobilis* var. *obtusa, Hydrophyllum virginianum, Elymus hystrix, Osmorhiza* spp., *Trillium grandiflorum, Viola* spp., *Dryopteris marginalis, Botrychium virginianum, Anemone quinquefolia, Geranium maculatum, Caulophyllum thalictroides, Sanguinaria canadensis, Claytonia virginica, Allium tricoccum, Cardamine concatenata, Arisaema triphyllum,* and *Laportea canadensis*.

Environmental Description: This community type occupies cool (northwest- to east-facing), mesic, lower to middle slopes, ravines, and coves at elevations from 425 to about 1050 m (1400–3450 feet). Sites may be underlain by a number of bedrock types, including limestone, dolomite, metabasalt (greenstone), granitic rocks, and sandstone. Slopes are typically steep (mean in plots = 23 degrees) and concave in at least one direction. Soils are deep, dark, and fertile, although frequently stony or bouldery. Samples collected from plots range from very strongly acidic to circumneutral (pH range = 4.2–6.8, mean pH = 5.3) but consistently have high calcium levels (mean = 1978 ppm) and moderately high magnesium and manganese levels.

Vegetation Description: The canopy is dominated by *Acer saccharum* with *Fraxinus americana* and *Tilia americana* being very characteristic. Associated canopy trees include

Quercus rubra, Ostrya virginiana, Ulmus rubra, Acer rubrum, Betula alleghaniensis, Betula lenta, Fagus grandifolia, Juglans nigra, Liriodendron tulipifera, Magnolia acuminata, Carya cordiformis, and *Prunus serotina*. The shrub layer is of variable composition, characterized by *Cornus alternifolia, Hamamelis virginiana, Lindera benzoin, Asimina triloba, Lonicera canadensis, Rhododendron periclymenoides*, and *Viburnum acerifolium*. The herb layer is diverse and made up of *Adiantum pedatum, Asarum canadense, Actaea racemosa, Cardamine* spp., *Hepatica nobilis* var. *obtusa, Hydrophyllum virginianum, Elymus hystrix, Osmorhiza* spp., *Trillium grandiflorum, Viola* spp., *Dryopteris marginalis, Botrychium virginianum, Anemone quinquefolia, Geranium maculatum, Caulophyllum thalictroides, Sanguinaria canadensis, Claytonia virginica, Allium tricoccum, Cardamine concatenata, Arisaema triphyllum*, and *Laportea canadensis*. More eastern stands in Kentucky contain *Aesculus flava, Aesculus glabra*, or *Tilia americana* var. *heterophylla* (Campbell 2001). In 15 plot-sampled Virginia stands, *Acer saccharum* and *Tilia americana* (including both var. *americana* and var. *heterophylla*) are consistently the most important canopy trees in mixed stands with *Fraxinus americana, Carya cordiformis, Quercus rubra*, and *Liriodendron tulipifera* (lower elevations only). Minor canopy associates vary with site conditions and geography. South of the James River, *Aesculus flava* is an occasional canopy tree. On higher and cooler sites, *Betula lenta, Fagus grandifolia*, and *Tsuga canadensis* may be present. *Juglans nigra* and *Ulmus rubra* occur occasionally at lower elevations. Understory layers usually contain a good representation of the canopy species, particularly *Acer saccharum*. The shrub layer is typically sparse to absent and no shrub species attained a constancy >47% or mean cover >5% in plots. The herb layer is lush and often exhibits patch dominance by a small number of species, particularly the spring-flowering forbs *Caulophyllum thalictroides* and *Osmorhiza claytonii*. Other characteristic aestival herbs include *Arisaema triphyllum, Asarum canadense, Dicentra* spp., *Galearis spectabilis, Hydrophyllum virginianum, Maianthemum racemosum, Podophyllum peltatum, Prosartes lanuginosa, Sanguinaria canadensis, Trillium grandiflorum, Uvularia grandiflora*, and *Viola canadensis*. The summer aspect is often dominated by large colonies of *Actaea racemosa, Impatiens pallida*, and/or *Laportea canadensis*. Species richness of plot-sampled stands ranges from 27 to 62 taxa per 400 square meters (mean = 41).

Most Abundant Species: Information not available.

Characteristic Species: *Acer saccharum, Actaea racemosa, Asarum canadense, Carya cordiformis, Caulophyllum thalictroides, Dicentra cucullaria, Fraxinus americana, Hydrophyllum virginianum, Impatiens pallida, Laportea canadensis, Lindera benzoin, Liriodendron tulipifera, Osmorhiza claytonii, Sanicula trifoliata, Tilia americana, Uvularia grandiflora, Viola canadensis.*

Other Noteworthy Species: *Aconitum reclinatum.*

USFWS Wetland System: None.

DISTRIBUTION

Range: This forest is found in the High Alleghenies, Western Allegheny Plateau, Central Appalachians, and Cumberlands from New York and New Jersey south to West Virginia, Virginia, and eastern Kentucky.

States/Provinces: KY, MD, NJ, NY, OH?, PA, VA, WV.

Federal Lands: NPS (Blue Ridge Parkway, Fort Necessity, Shenandoah); USFS (Daniel Boone, George Washington, Jefferson).

CONSERVATION STATUS
Rank: G4? (28-Sep-2001).
Reasons: This unit has a fairly wide geographic range, within which it is regularly distributed as a small- to large-patch vegetation type in suitably fertile habitats. Because of excellent site conditions for tree growth, stands are very vulnerable to logging and are further threatened by shade-tolerant exotic weeds.

CLASSIFICATION INFORMATION
Status: Standard.
Confidence: 2 – Moderate.
Comments: Despite considerable compositional variation, this unit appears to be a widespread and robust vegetation type. Damman and Kershner (1977) describe similar vegetation from gneissic areas of western Connecticut, with key species including *Acer saccharum, Tilia americana, Fraxinus americana, Liriodendron tulipifera, Lindera benzoin, Carpinus caroliniana, Ulmus rubra, Carya cordiformis, Osmorhiza claytonii, Asarum canadense, Caulophyllum thalictroides, Hepatica nobilis* var. *obtusa, Galearis spectabilis, Viola pubescens*, and *Deparia acrostichoides*. The Sugar Maple - Basswood - Tuliptree Community described by Martin (1975) from southeastern Kentucky, and the *Acer saccharum - Liriodendron tulipifera - Fraxinus americana* Community described by Andreu and Tuckman (1995) from the Tellico Lake area of eastern Tennessee are similar, but not fully comparable because only woody vegetation was analyzed in these studies.

In extreme southwestern Virginia, this community type is gradational to *~Aesculus flava - Acer saccharum - (Fraxinus americana, Tilia americana* var. *heterophylla) / Hydrophyllum canadense - Solidago flexicaulis* Forest (CEGL007695) of high-elevation coves in the Southern Appalachians. However, CEGL006237 may be distinguished by generally occurring at much lower elevations, having lower species richness, and lacking (or nearly lacking) a number of primarily southern species prominent in CEGL007695, including *Actaea podocarpa, Aesculus flava, Hydrophyllum canadense, Phacelia fimbriata, Phlox stolonifera, Sanicula odorata, Stachys nuttallii*, and *Trillium sulcatum*. A few occurring frequently in CEGL006237 (especially its high-elevation subtype), including *Aconitum reclinatum, Betula alleghaniensis, Piptatherum racemosum*, and *Sanicula trifoliata*, are absent or uncommon in CEGL007695.

The exotic weed *Alliaria petiolata* is a rampant invader of some stands of this vegetation on the Northern Blue Ridge.
Similar Associations:
Acer saccharum - Liriodendron tulipifera - Fraxinus americana / Staphylea trifolia Forest (CEGL006201)
Aesculus flava - Acer saccharum - (Fraxinus americana, Tilia americana var. *heterophylla) / Hydrophyllum canadense - Solidago flexicaulis* Forest (CEGL007695)
Related Concepts:
Acer saccharum - Betula alleghaniensis / Acer pensylvanicum / Laportea canadensis - Angelica triquinata Forest (Fleming and Coulling 2001) ?
Acer saccharum - Tilia americana / Caulophyllum thalictroides - Laportea canadensis - Osmorhiza claytonii Forest (Fleming and Coulling 2001) ?
Acer saccharum - Tilia americana / Laportea canadensis - Caulophyllum thalictroides - Deparia acrostichoides Forest (Coulling and Rawinski 1999) ?

Acer saccharum var. *saccharum* - *Tilia americana / Laportea canadensis* - *Caulophyllum thalictroides* - *Trillium grandiflorum* Forest (type 1.3) (Fleming 1999) ?
Liriodendron tulipifera - *Acer saccharum* - *Tilia americana / Laportea canadensis* - *Impatiens pallida* Association, *pro parte* (Rawinski et al. 1996) ?
Sugar Maple - Basswood: 26 (Eyre 1980) B
Sugar maple-white ash-basswood cove forest (matrix/large patch) (CAP pers. comm. 1998) ?

SOURCES

Description Authors: G. Fleming and P. Coulling.

References: Anderson et al. 1998, Breden et al. 2001, CAP pers. comm. 1998, Campbell 2001, Coulling and Rawinski 1999, Damman and Kershner 1977, Eastern Ecology Working Group n.d., Edinger et al. 2002, Eyre 1980, Fike 1999, Fleming 1999, Fleming and Coulling 2001, Fleming et al. 2001, Lundgren 2000, Martin 1975, Rawinski et al. 1996.

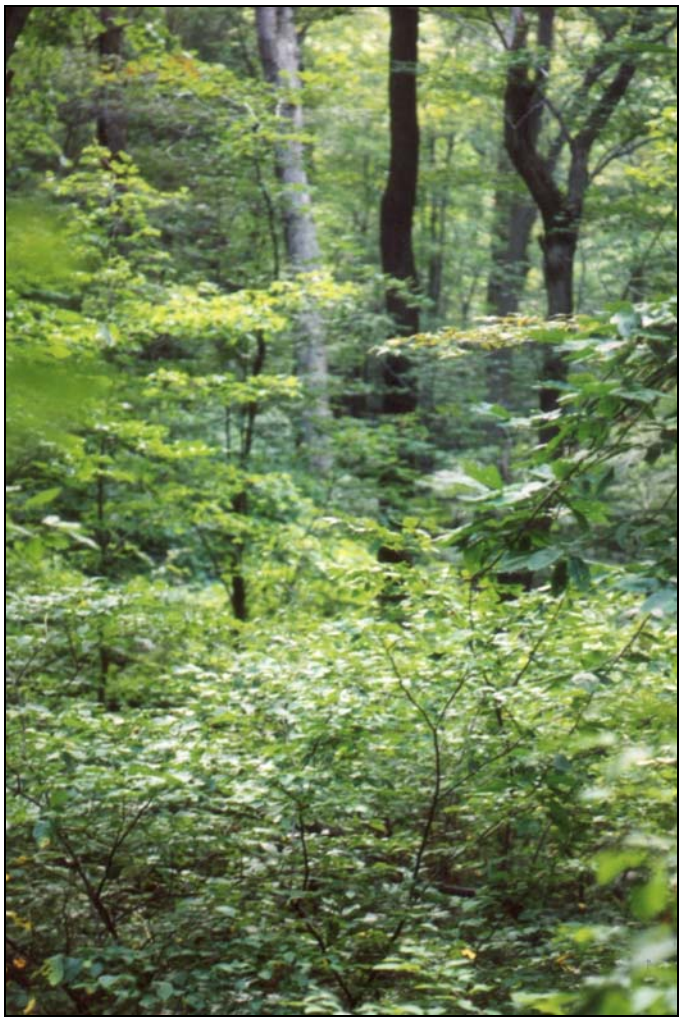

Figure 12. Sugar Maple – Basswood Forest at the Jumonville Glen Unit of Fort Necessity National Battlefield (plot FONE.31). August 2003. NAD 1983 / UTM easting 616312, northing 4415385.

Common Name (Park-specific): Tuliptree Forest

SYNONYMS

NVC English Name:	**Tuliptree - Northern Red Oak - Cucumber-tree / Flowering Dogwood Forest**
NVC Scientific Name:	***Liriodendron tulipifera - Quercus rubra - Magnolia acuminata / Cornus florida* Forest**
NVC Identifier:	**CEGL008510**

LOCAL INFORMATION

Environmental Description: This forest type is generally found on mid to lower slopes in Fort Necessity National Battlefield and on recently abandoned agricultural land situated on high-elevation, level sites.

Vegetation Description: The dominant tree in this community is tuliptree (*Liriodendron tulipifera*), although it also shares dominance with red maple (*Acer rubrum*), black cherry (*Prunus serotina*) and northern red oak (*Quercus rubra*). Other occasional canopy species include: pignut hickory (*Carya glabra*), shagbark hickory (*Carya ovata*), sugar maple (*Acer saccharum*) and cucumber-tree (*Magnolia acuminata*). The canopy may be divided into three layers: an emergent layer (30–36m in height) that covers 20–60% of the stand; the canopy that can extend from 18 to 30 m in height and covers 60–80% of the area; and a subcanopy (5–20m in height) that covers 20–60% of the stand. Beneath the canopy, black cherry, red maple, cucumber-tree , sweet birch (*Betula lenta*), white ash (*Fraxinus americana*), American chestnut (*Castanea dentata*), American elm (*Ulmus americana*), common serviceberry (*Amelanchier arborea*) and southern arrowwood (*Viburnum dentatum* var. *lucidum*) form a sparse tall shrub layer. The short shrub layer cover 10–80% of the area and contains a diversity of tree seedlings and shrubs. The most common short shrub species are the invasive species multiflora rose (*Rosa multiflora*), Morrow's honeysuckle (*Lonicera morrowii*), and Japanese barberry (*Berberis thunbergii*), as well as mapleleaf viburnum (*Viburnum acerifolium*), southern arrowwood (*Viburnum dentatum* var. *lucidum*), northern dewberry (*Rubus flagellaris*), Allegheny blackberry (*Rubus allegheniensis*), and bristly dewberry (*Rubus hispidus*). Ericaceous species such as black huckleberry (*Gaylussacia baccata*) and Blue Ridge blueberry (*Vaccinium pallidum*) can be found in low abundance in some examples of this community. Herbaceous cover is typically high (50–80%) and species composition varies between locations. Eastern hayscented fern (*Dennstaedtia punctilobula*), clubmoss (*Lycopodium digitatum*), colonial bentgrass (*Agrostis capillaris*), white snakeroot (*Ageratina altissima* var. *altissima*), New York fern (*Thelypteris noveboracensis*), common cinquefoil (*Potentilla simplex*), spotted ladysthumb (*Polygonum persicaria*), black bugbane (*Actaea racemosa*), sedges (*Carex swanii, C. gracillima*), fan clubmoss (*Lycopodium digitatum*), jumpseed (*Polygonum virginianum*), and white rattlesnakeroot (*Prenanthes alba*) are common species in the herbaceous layer. Eastern poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax glauca, S. rotundifolia*), grape (*Vitis* spp.), and Virginia creeper (*Parthenocissus quinquefolia*) are the vine species found in low abundance throughout this forest type.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Liriodendron tulipifera, Acer rubrum, Quercus rubra, Prunus serotina*
Tree subcanopy	Broad-leaved deciduous tree	*Liriodendron tulipifera, Acer rubrum*
Tall shrub/sapling	Broad-leaved deciduous tree	*Acer rubrum*
Short shrub/sapling	Broad-leaved deciduous shrub	*Rosa multiflora, Lonicera morrowii, Berberis thunbergii, Gaylussacia baccata, Vaccinium pallidum*
Herb (field)	Forb	*Dennstaedtia punctilobula, Thelypteris noveboracensis, Lycopodium digitatum, Ageratina altissima* var. *altissima*
Herb (field)	Graminoid	*Agrostis capillaris*

Characteristic Species: *Liriodendron tulipifera, Acer rubrum, Quercus rubra, Prunus serotina, Rosa multiflora, Lonicera morrowii, Berberis thunbergii, Gaylussacia baccata, Vaccinium pallidum*.

Other Noteworthy Species: Information not available.

Local Range: This common forest type is generally found throughout the main unit of Fort Necessity National Battlefield.

Classification Comments: Tuliptree Forest is distinguished from other hardwood forests by the dominance of *Liriodendron tulipifera* covering 15–80% of the forest stand, while *Quercus* spp. cover less than 50% of the stand.

Other Comments: None.

Local Description Authors: S. J. Perles (PNHP).

Plots: FONE.1, FONE.8, FONE.10, FONE.16, FONE.18, FONE.47.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Forest (I)
Physiognomic Subclass	Deciduous forest (I.B.)
Physiognomic Group	Cold-deciduous forest (I.B.2.)
Physiognomic Subgroup	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
Formation	Lowland or submontane cold-deciduous forest (I.B.2.N.a.)
Alliance	*Liriodendron tulipifera* Forest Alliance (A.236)
Alliance (English name)	Tuliptree Forest Alliance
Association	*Liriodendron tulipifera - Quercus rubra - Magnolia acuminata / Cornus florida* Forest
Association (English name)	Tuliptree - Northern Red Oak - Cucumber-tree / Flowering Dogwood Forest
Association (Common name)	Central Appalachian Rich Cove Forest (Tuliptree - Northern Red Oak - Cucumber-tree Type)
Ecological System(s):	Southern and Central Appalachian Cove Forest (CES202.373)

GLOBAL DESCRIPTION

Concept Summary: This Central Appalachian community type occurs throughout the Blue Ridge and Ridge and Valley portion of the Virginia mountains north of the New River and may extend throughout the central Appalachian portions of West Virginia, Maryland, and Pennsylvania. Stands occupy mesic hollow sideslopes, ravines, and slope concavities at elevations from 240–800 m (800–2600 feet) and exceptionally to 1000 m (3300 feet). Underlying bedrock is variable and probably exerts less influence on vegetation than local soil conditions. Stands are associated both with sheltered sites on poor substrates, such as acidic sandstones, and with warmer, more exposed coves on fertile substrates. Vegetation consists largely of post-logging secondary forests with tall (>30 m), well-formed canopy trees. *Liriodendron tulipifera* is the characteristic, usually dominant canopy species in mixed stands with *Magnolia acuminata, Quercus rubra, Acer rubrum*, and *Carya ovalis*. *Quercus prinus, Fraxinus americana, Betula lenta, Tilia americana* (including both var. *americana* and var. *heterophylla*), *Carya glabra, Carya alba*, and *Quercus alba* are minor canopy associates. Understory tree layers are very open and contain young reproduction of the canopy species along with *Cornus florida* (often dominant) and *Ostrya virginiana*. *Cornus florida, Viburnum acerifolium*, and climbing or scrambling *Parthenocissus quinquefolia* are usually the most abundant species of a sparse shrub layer. The herb layer varies in density from open to moderately dense, but generally lacks the lush aspect of other communities in the Rich Cove and Slope Forests group.

Environmental Description: Stands occupy mesic hollow sideslopes, ravines, and slope concavities at elevations from 240–800 m (800–2600 feet) and exceptionally to 1000 m (3300 feet). Underlying bedrock is variable and probably exerts less influence on vegetation than local soil conditions. Stands are associated both with sheltered sites on poor substrates, such as acidic sandstones, and with warmer, more exposed coves on fertile substrates. Surface boulder and stone cover averages about 14% in plots but can range up to 75% in extreme situations. Slopes are steep (mean = 20 degrees) and typically concave in at least one direction. Soils mapped at plot-sampling sites are mostly deep, very stony colluvial loams. Samples collected from plots range from very strongly to slightly acidic (mean pH = 5.2) but have moderately high calcium (mean = 1044 ppm) and magnesium (mean = 136 ppm) levels.

Vegetation Description: Vegetation consists largely of post-logging secondary forests with tall (>30 m), well-formed canopy trees. *Liriodendron tulipifera* is the characteristic, usually dominant canopy species in mixed stands with *Magnolia acuminata, Quercus rubra, Acer rubrum*, and *Carya ovalis*. *Quercus prinus, Fraxinus americana, Betula lenta, Tilia americana* (including both var. *americana* and var. *heterophylla*), *Carya glabra, Carya alba*, and *Quercus alba* are minor canopy associates. Understory tree layers are very open and contain young reproduction of the canopy species along with *Cornus florida* (often dominant) and *Ostrya virginiana*. *Cornus florida, Viburnum acerifolium*, and climbing or scrambling *Parthenocissus quinquefolia* are usually the most abundant species of a sparse shrub layer. The herb layer varies in density from open to moderately dense, but generally lacks the lush aspect of other communities in the Rich Cove and Slope Forests group. The most constant (>50% constancy) herbs in 15 Virginia plots of this vegetation are *Dioscorea quaternata, Actaea racemosa, Desmodium nudiflorum, Amphicarpaea bracteata, Solidago curtisii, Eurybia divaricata, Polystichum acrostichoides, Geranium maculatum, Sanguinaria canadensis, Botrychium virginianum, Brachyelytrum erectum, Uvularia perfoliata, Galium triflorum*, and *Maianthemum racemosum*. Less constant but locally important herbaceous components include *Adiantum*

pedatum, Osmunda claytoniana, Ligusticum canadense, Thalictrum thalictroides, and *Phegopteris hexagonoptera*. Species richness of plot-sampled stands ranges from 38 to 95 taxa per 400 m2 (mean = 51).
Most Abundant Species: Information not available.
Characteristic Species: *Actaea racemosa, Amphicarpaea bracteata, Cornus florida, Liriodendron tulipifera, Magnolia acuminata, Sanguinaria canadensis, Thaspium trifoliatum, Viburnum acerifolium*.
Other Noteworthy Species: *Aconitum reclinatum*.
USFWS Wetland System: None.

DISTRIBUTION
Range: This community type occurs throughout the Blue Ridge and Ridge and Valley portion of the Virginia mountains north of the New River. Its potential range extends throughout the central Appalachian portions of West Virginia, Maryland, and Pennsylvania.
States/Provinces: MD?, PA, VA:S5, WV?
Federal Lands: NPS (Blue Ridge Parkway, Fort Necessity); USFS (George Washington, Jefferson).

CONSERVATION STATUS
Rank: G5? (21-Jun-2001).
Reasons: This vegetation type is widely and extensively distributed at lower elevations in the Virginia mountain region and likely extends throughout much of the central Appalachians.

CLASSIFICATION INFORMATION
Status: Standard.
Confidence: 2 – Moderate.
Comments: Both in terms of floristics and soil fertility, this unit represents the least `rich' community type in the Rich Cove and Slope Forests group. Its classification and ecological interpretation are complicated by past logging, which in most situations has greatly favored the reproduction of the shade-intolerant *Liriodendron tulipifera* and *Magnolia acuminata*. Yet, there does not seem to be a consistent or obvious successional pattern in most stands of the association. Potential successors might include several *Quercus* spp., *Carya* spp., and *Tilia americana*. Given the current dominance and longevity of *Liriodendron tulipifera* and its persistence even in mature cove hardwood stands, successional change in this association will be slow.

Old *Castanea dentata* stumps and wood debris were recorded in some plots of this type. Although most forests of this association were cut long ago because of their accessibility and fine timber, a few small patches of old growth persist on the steep, hollowed slopes of Peters Mountain in Alleghany County (Fleming and Moorhead 2000). Based on an examination of these old stands, it appears that the original forest canopies on Peters Mountain were mixed associations of *Quercus rubra, Quercus prinus, Castanea dentata*, and *Liriodendron tulipifera*. The latter was probably able to maintain a position in these mixed forests because of its rapid growth and superior ability to colonize light gaps caused by downfalls (Busing 1995, Fowells 1965).
Similar Associations: Information not available.

Related Concepts:

Liriodendron tulipifera - Magnolia acuminata / Cornus florida / Osmunda claytoniana Forest (Fleming and Moorhead 2000) ?

Liriodendron tulipifera - Quercus rubra - Magnolia acuminata / Cornus florida Forest (Fleming and Coulling 2001) =

Liriodendron tulipifera / Cornus florida / Lindera benzoin / Actaea racemosa Association, *pro parte* (Rawinski et al. 1996) ?

Yellow-poplar - White Oak - Northern Red Oak: 59 (Eyre 1980) B

Yellow-poplar: 57 (Eyre 1980) B

SOURCES

Description Authors: G. Fleming.

References: Busing 1995, Eyre 1980, Fleming and Coulling 2001, Fleming and Moorhead 2000, Fleming et al. 2001, Fowells 1965, Rawinski et al. 1996.

Figure 13. Tuliptree Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.8). July 2003. NAD 1983 / UTM easting 620547, northing 4407534.

Figure 14. Tuliptree Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.16). July 2003. NAD 1983 / UTM easting 620726, northing 4407293.

Common Name (Park-specific): Red Maple – Black Cherry Successional Forest

SYNONYMS
NVC English Name: **Black Cherry - Tuliptree - Red Maple - White Ash Forest**
NVC Scientific Name: ***Prunus serotina - Liriodendron tulipifera - Acer rubrum - Fraxinus americana* Forest**
NVC Identifier: **CEGL006599**

LOCAL INFORMATION

Environmental Description: This variable vegetation type is found in several topographic positions throughout Fort Necessity National Battlefield and is heavily influenced by land-use history. These stands occur on former agricultural land that has developed into forest and on sites from which the formerly dominant oaks (*Quercus* spp.) have been harvested.
Vegetation Description: The dominance of black cherry (*Prunus serotina*) and red maple (*Acer rubrum*) throughout the canopy is diagnostic for this community type. These forests typically have three layers of tree canopy: an emergent layer (23–27m in height) that covers 5–40% of the stand; the canopy that can extend from 12 to 24 m in height and covers 15–75% of the area; and a subcanopy (8–15m in height) that covers 10–25% of the stand. In addition, many other hardwood and conifer species can be found scattered throughout the canopy of this forest type. Black locust (*Robinia pseudoacacia*) is a common co-dominant in weedy stands. Often, large scattered open grown white oaks (*Quercus alba*) form a sparse emergent layer above the maples and cherries. In stands established after the removal of oaks, tuliptree (*Liriodendron tulipifera),* sugar maple (*Acer saccharum*) and oaks may be present. These harvested stands can also contain serviceberries (*Amelanchier* spp.), American hornbeam (*Carpinus caroliniana*), sweet birch (*Betula lenta*), southern arrowwood (*Viburnum dentatum* var. *lucidum*) and northern spicebush (*Lindera benzoin*) in the subcanopy and tall shrub layers. The tall shrub layer is typically sparse (15–30% cover), although young weedy stands can contain a thick shrub layer of hawthorns (*Crataegus* spp.) and apples (*Malus* spp.). Most of the species found in the tree canopy and subcanopy will also occur in the short shrub layer, along with the invasive species multiflora rose (*Rosa multiflora*), Morrow's honeysuckle (*Lonicera morrowii*), and Japanese barberry (*Berberis thunbergii*), and the native shrubs bristly dewberry (*Rubus hispidus*), northern dewberry (*Rubus flagellaris*), and Allegheny blackberry (*Rubus allegheniensis*). The species composition of the herbaceous layer (10–80% cover) varies widely with soil drainage and land use history. Some common species include: New York fern (*Thelypteris noveboracensis*), flattened oatgrass (*Danthonia compressa*), spotted ladythumb (*Polygonum persicaria*), white snakeroot (*Ageratina altissima* var. *altissima*), deertongue (*Dichanthelium clandestinum*), common cinquefoil (*Potentilla simplex*), common blue violet (*Viola sororia*), common yellow oxalis (*Oxalis stricta*), eastern hayscented fern (*Dennstaedtia punctilobula*), intermediate woodfern (*Dryopteris intermedia*), spinulose woodfern (*Dryopteris carthusiana*), and Swan's sedge (*Carex swanii*). Vines are typically in low abundance; eastern poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax glauca, S. rotundifolia, S. tamnoides*), grape (*Vitis* spp.), and Virginia creeper (*Parthenocissus quinquefolia*) are the common vine species in this type. The disturbed nature of this community tends to encourage the spread of invasive species, primarily Morrow's honeysuckle, multiflora rose, and Japanese barberry.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Prunus serotina, Acer rubrum, Robinia pseudoacacia*
Tree subcanopy	Broad-leaved deciduous tree	*Prunus serotina, Acer rubrum, Amelanchier* spp., *Crataegus* spp.
Tall shrub/sapling	Broad-leaved deciduous shrub	*Crataegus* spp., *Prunus serotina, Acer rubrum, Amelanchier* spp.
Short shrub/sapling	Broad-leaved deciduous shrub	*Rosa multiflora, Lonicera morrowii, Berberis thunbergii, Rubus* spp.
Herb (field)	Forb	*Thelypteris noveboracensis, Polygonum persicaria, Ageratina altissima* var. *altissima, Potentilla simplex*
Herb (field)	Graminoid	*Danthonia compressa, Panicum clandestinum*

Characteristic Species: *Prunus serotina, Acer rubrum, Robinia pseudoacacia, Crataegus* spp.
Other Noteworthy Species: Information not available.
Local Range: This common and variable association is found throughout Fort Necessity National Battlefield.
Classification Comments: Red Maple – Black Cherry Successional Forest is distinguished from other types by its canopy that covers >60% of the stand and is dominated by *Prunus serotina, Acer rubrum,* and/or *Robinia pseudoacacia.*
Other Comments: None.
Local Description Authors: S. J. Perles (PNHP).
Plots: FONE.13, FONE.24, FONE.25, FONE.28, FONE.43, FONE.44, FONE.45, FONE.46.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Forest (I)
Physiognomic Subclass	Deciduous forest (I.B.)
Physiognomic Group	Cold-deciduous forest (I.B.2.)
Physiognomic Subgroup	Natural/Semi-natural cold-deciduous forest (I.B.2.N.)
Formation	Lowland or submontane cold-deciduous forest (I.B.2.N.a.)
Alliance	*Prunus serotina - Acer rubrum - Amelanchier canadensis – Quercus* spp. Forest Alliance (A.237)
Alliance (English name)	Black Cherry - Red Maple - Canada Serviceberry - Oak species Forest Alliance
Association	*Prunus serotina - Liriodendron tulipifera - Acer rubrum - Fraxinus americana* Forest
Association (English name)	Black Cherry - Tuliptree - Red Maple - White Ash Forest
Association (Common name)	Northeastern Modified Successional Forest
Ecological System(s):	Information not available

GLOBAL DESCRIPTION

Concept Summary: This early-successional woody vegetation of the northeastern United States occurs on sites that have generally been cleared for agriculture. Environmental setting varies, but generally sites are dry-mesic to mesic, with small seepage inclusions in some examples. Physiognomy of this vegetation is highly variable, ranging from closed forest, open forest, tall dense shrubland, to more open tall shrubland. Early-successional woody species dominate the canopy in a widely variable mix, depending on geographic location. Tree species may include *Prunus serotina, Liriodendron tulipifera, Fraxinus americana,* and *Acer rubrum*. Other associates can include *Juglans nigra, Sassafras albidum, Betula populifolia, Juniperus virginiana, Acer negundo, Acer saccharinum, Ailanthus altissima, Ulmus americana, Quercus* spp., *Betula lenta, Amelanchier* spp., and *Robinia pseudoacacia*. Other woody species may contribute to the canopy or form a tall-shrub layer, including *Lindera benzoin* and *Carpinus caroliniana*. The low-shrub layer, if present, is usually characterized by the presence of *Rubus* spp. such as *Rubus flagellaris, Rubus allegheniensis, Rubus phoenicolasius,* or *Rubus hispidus*. This layer is often dominated by exotic species such as *Lonicera tatarica, Lonicera japonica, Rhamnus cathartica, Crataegus* spp., *Rosa multiflora,* and *Berberis thunbergii*. The herbaceous layer is variable, often containing grasses and forbs of both native and exotic origin.
Environmental Description: This vegetation occurs on sites that have been cleared for agriculture or otherwise heavily modified in the past. Generally sites are dry-mesic and may have small seepage inclusions in some examples.
Vegetation Description: Information not available.
Most Abundant Species: Information not available.
Characteristic Species: Information not available.
Other Noteworthy Species: Information not available.
USFWS Wetland System: None.

DISTRIBUTION

Range: This vegetation is currently described from Pennsylvania but is of broader distribution in the northeastern U.S.
States/Provinces: NJ, NY, PA.
Federal Lands: NPS (Fort Necessity, Johnstown Flood, Morristown, Valley Forge).

CONSERVATION STATUS

Rank: GNA (ruderal) (29-Nov-2004).
Reasons: This vegetation is modified by human activity and not of conservation concern.

CLASSIFICATION INFORMATION

Status: Standard.
Confidence: 3 – Weak.
Comments: This vegetation is broadly defined and varies widely in composition across its range, presenting a classification challenge at the alliance level.
Similar Associations: Information not available.
Related Concepts: Information not available.

SOURCES

Description Authors: L. A. Sneddon.
References: Eastern Ecology Working Group n.d., Fike 1999.

Figure 15. Red Maple – Black Cherry Successional Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.13). July 2003. NAD 1983 / UTM easting 621271, northing 4408041.

Figure 16. Red Maple – Black Cherry Successional Forest at the Main Unit of Fort Necessity National Battlefield (plot FONE.45). September 2003. NAD 1983 / UTM easting 621882, northing 4407497.

COMMON NAME (PARK-SPECIFIC): CONIFER PLANTATION

SYNONYMS
NVC English Name: **Conifer Plantation**
NVC Scientific Name: **Conifer Plantation**
NVC Identifier: **CEGL006313**

LOCAL INFORMATION

Environmental Description: Several conifer plantations have been established in Fort Necessity National Battlefield and are currently in various stages of management.
Vegetation Description: Red pine (*Pinus resinosa*), white pine (*Pinus strobus*), Norway spruce (*Picea abies*) and Japanese larch (*Larix kaempferi*) were commonly planted in these stands. In well-stocked stands, tree canopy cover will be between 70–90%. Emergent and subcanopy trees typically also cover 10–40% of the area. In the past ten years, ice-storm damage and silvicultural thinnings have allowed adventitious hardwoods to establish, creating mixed hardwood-conifers stands. The composition of the adventitious hardwood species differs considerably due to the edaphic characteristics of the site, the degree of management or disturbance, and the type of conifer planted. Spruce plantations commonly have a very sparse low short shrub and herbaceous layers. In contrast, the percent cover of woody and herbaceous species is markedly larger in successional pine plantations. Common hardwoods in these communities are black cherry (*Prunus serotina*), red maple (*Acer rubrum*), and white ash (*Fraxinus americana*). A tall shrub layer (2–5m in height) may be present and cover up to 45% of the stand. Red maple, black cherry, white ash, hawthorns (*Crataegus* spp.), American hornbeam (*Carpinus caroliniana*), Morrow's honeysuckle (*Lonicera morrowii*), American witchhazel (*Hamamelis virginiana*), and northern spicebush (*Lindera benzoin*) are common tall shrubs. Most of the tall shrub species also appear as short shrubs (0.1–2m in height) that can cover up to 35% of the stand. A wide diversity of hardwood and evergreen tree seedlings are also found in short shrub layer. The most common short shrubs include: Japanese barberry (*Berberis thunbergii*), Morrow's honeysuckle, multiflora rose (*Rosa multiflora*), northern spicebush, southern arrowwood (*Viburnum dentatum* var. *lucidum*), Blue Ridge blueberry (*Vaccinium pallidum*), bristly dewberry (*Rubus hispidus*) and northern dewberry (*Rubus flagellaris*). The species composition and abundance of the herbaceous layer varies widely due to variation in canopy tree species composition, stand stocking, and soil drainage. Herbaceous species can cover up to 90% of the stand in some areas. White snakeroot (*Ageratina altissima* var. *altissima*), intermediate woodfern (*Dryopteris intermedia*), spinulose woodfern (*Dryopteris carthusiana*), common yellow oxalis (*Oxalis stricta*), common cinquefoil (*Potentilla simplex*), partridgeberry (*Mitchella repens*), cleavers (*Galium aparine*), rough bedstraw (*Galium asprellum*), bearded shorthusk (*Brachyelytrum erectum*), and fan clubmoss (*Lycopodium digitatum*) are some common species in the herbaceous layer. However, graminoid and herbaceous species associated with disturbed areas such as creeping bentgrass (*Agrostis stolonifera*), common velvetgrass (*Holcus lanatus*), deertongue (*Dichanthelium clandestinum*), eastern hayscented fern (*Dennstaedtia punctilobula*) and common St. Johnswort (*Hypericum perforatum*) are often dominant in these communities. In areas with poor soil drainage, hydrophilic species may dominate, including common rush (*Juncus effusus*), reed canarygrass (*Phalaris arundinacea*), whitegrass (*Leersia virginica*) and golden ragwort (*Packera aurea*). Vines such as eastern poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax glauca, S. rotundifolia*), summer grape (*Vitis aestivalis*), and Virginia creeper

(*Parthenocissus quinquefolia*) may be present, but not abundant, in these plantations. The disturbance from the silvicultural treatments and the fragmented nature of this park leave these communities prone to invasion by exotic species, including: Morrow's honeysuckle, multiflora rose, and Japanese barberry.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Needle-leaved evergreen tree	*Pinus resinosa, Pinus strobus, Picea abies, Larix kaempferi*
Tree subcanopy	Broad-leaved deciduous tree	*Acer rubrum, Prunus serotina, Fraxinus americana*
Tall shrub/sapling	Broad-leaved deciduous shrub	*Acer rubrum, Prunus serotina, Crataegus* spp., *Carpinus caroliniana, Lonicera morrowii, Hamamelis virginiana*
Short shrub/sapling	Broad-leaved deciduous shrub	*Berberis thunbergii, Lindera benzoin, Rubus* spp.
Herb (field)	Forb	*Ageratina altissima* var. *altissima, Dryopteris* spp., *Polystichum acrostichoides, Galium* spp., *Mitchella repens*
Herb (field)	Graminoid	*Brachyelytrum erectum, Panicum clandestinum, Agrostis stolonifera*

Characteristic Species: *Pinus resinosa, Pinus strobus, Picea abies, Larix kaempferi*.

Other Noteworthy Species: Information not available.

Local Range: This common association is found throughout the main unit of Fort Necessity National Battlefield.

Classification Comments: Conifer Planatations are identified by the dominance of *Pinus resinosa, Pinus strobus, Picea abies, Larix kaempferi*. This type does not have a NVCS crosswalk, as it is a local type only.

Other Comments: None.

Local Description Authors: S. J. Perles (PNHP).

Plots: : FONE.5, FONE.14, FONE.15, FONE.23, FONE.26, FONE.27.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Forest (I)
Physiognomic Subclass	Evergreen forest (I.A.)
Physiognomic Group	Temperate or subpolar needle-leaved evergreen forest (I.A.8.)
Physiognomic Subgroup	Planted/Cultivated temperate or subpolar needle-leaved evergreen forest (I.A.8.C.)
Formation	Planted/cultivated temperate or subpolar needle-leaved evergreen forest (I.A.8.C.x.)
Alliance	*Pinus strobus* Planted Forest Alliance (A.98)
Alliance (English name)	Eastern White Pine Planted Forest Alliance
Association	*Pinus* spp. Planted Forest
Association (English name)	Pine species Planted Forest

Association (Common name) Mixed Pine Conifer Plantation
Ecological System(s): Information not available

GLOBAL DESCRIPTION

Concept Summary: These plantations consist of mature *Pinus strobus* or *Pinus sylvestris*, with other conifers sometimes present in smaller amounts, planted in post-agricultural fields and pastures. Associated canopy conifers include *Pinus resinosa, Picea abies*, or *Larix decidua*. The understory varies widely in its degree of development and may be virtually absent. Northern hardwoods typically dominate the sapling and seedling layers, and cover is proportional to the degree of canopy break-up or opening that has occurred. Common hardwoods include *Prunus serotina, Acer rubrum*, and *Fraxinus americana*. A tall-shrub layer may be present; common species (aside from smaller individuals of the hardwood saplings) include *Crataegus* spp., *Hamamelis virginiana*, and *Lindera benzoin*. Common short shrubs include *Viburnum dentatum* var. *lucidum, Vaccinium pallidum, Rubus hispidus*, and *Rubus flagellaris*. The species composition and abundance of the herbaceous layer vary widely due to variation in canopy tree species composition, stand stocking, and soil drainage. Herbaceous species include *Ageratina altissima* var. *altissima, Dryopteris intermedia, Dryopteris carthusiana, Oxalis stricta, Potentilla simplex, Mitchella repens, Galium aparine, Galium asprellum, Brachyelytrum erectum*, and *Lycopodium digitatum*. Graminoid and forb species associated with disturbed areas, such as *Agrostis stolonifera, Dichanthelium clandestinum, Dennstaedtia punctilobula*, and *Hypericum perforatum*, are often dominant in these communities. Vines such as *Toxicodendron radicans, Smilax glauca, Smilax rotundifolia, Vitis* spp., and *Parthenocissus quinquefolia* may be present, but not abundant, in these plantations. Disturbance from the silvicultural treatments and landscape fragmentation leave these communities prone to invasion by exotic species, including *Lonicera tatarica, Berberis vulgaris*, and *Rosa multiflora*, which are locally abundant in places.

Environmental Description: These mature plantations are planted in post-agricultural fields and pastures.

Vegetation Description: These plantations consist of mature *Pinus strobus* or *Pinus sylvestris*, with other conifers sometimes present in smaller amounts, planted in post-agricultural fields and pastures. Associated canopy conifers include *Pinus resinosa, Picea abies*, or *Larix decidua*. The understory varies widely in its degree of development and may be virtually absent. Northern hardwoods typically dominate the sapling and seedling layers, and cover is proportional to the degree of canopy break-up or opening that has occurred. Common hardwoods include *Prunus serotina, Acer rubrum*, and *Fraxinus americana*. A tall-shrub layer may be present; common species (aside from smaller individuals of the hardwood saplings) include *Crataegus* spp., *Hamamelis virginiana*, and *Lindera benzoin*. Common short shrubs include *Viburnum dentatum* var. *ludidum, Vaccinium pallidum, Rubus hispidus*, and *Rubus flagellaris*. The species composition and abundance of the herbaceous layer vary widely due to variation in canopy tree species composition, stand stocking, and soil drainage. Herbaceous species include *Ageratina altissima* var. *altissima, Dryopteris intermedia, Dryopteris carthusiana, Oxalis stricta, Potentilla simplex, Mitchella repens, Galium aparine, Galium asprellum, Brachyelytrum erectum*, and *Lycopodium digitatum*. Graminoid and forb species associated with disturbed areas, such as *Agrostis stolonifera, Dichanthelium clandestinum, Dennstaedtia punctilobula*, and *Hypericum perforatum*, are often dominant in these communities. Vines such as *Toxicodendron radicans, Smilax glauca, Smilax rotundifolia, Vitis* spp., and *Parthenocissus quinquefolia* may be present, but not abundant, in these plantations. Disturbance from the silvicultural treatments and

landscape fragmentation leave these communities prone to invasion by exotic species, including *Lonicera tatarica*, *Berberis vulgaris*, and *Rosa multiflora*, which are locally abundant in places.

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Needle-leaved tree	*Pinus strobus*, *Pinus sylvestris*

Characteristic Species: *Pinus strobus*, *Pinus sylvestris*.

Other Noteworthy Species: Information not available.

USFWS Wetland System: Not applicable.

DISTRIBUTION

Range: Information not available.

States/Provinces: PA, VT.

Federal Lands: NPS (Allegheny Portage Railroad, Delaware Water Gap, Fort Necessity, Friendship Hill, Johnstown Flood, Marsh-Billings-Rockefeller).

CONSERVATION STATUS

Rank: GNA (modified/managed) (1-Dec-2004).

Reasons: Information not available.

CLASSIFICATION INFORMATION

Status: Standard.

Confidence: 3 – Weak.

Comments: This type is intended for plantations of mixed pines or pine mixed with other non-native planted conifers.

Similar Associations:

- *Pinus strobus* Planted Forest (CEGL007178)--monotypic white pine.

Related Concepts: Information not available.

SOURCES

Description Authors: S.C. Gawler.

References: Eastern Ecology Working Group n.d., Perles et al. 2006a, Perles et al. 2006b, Podniesinski et al. 2006.

Figure 17. Conifer Plantation at the Main Unit of Fort Necessity National Battlefield (plot FONE.15). July 2003. NAD 1983 / UTM easting 621054, northing 4407925.

Figure 18. Conifer Plantation at the Braddock's Grave Unit of Fort Necessity National Battlefield (plot FONE.27). August 2003. NAD 1983 / UTM easting 619683, northing 4410131.

COMMON NAME (PARK-SPECIFIC): SUCCESSIONAL OLD FIELD

SYNONYMS
NVC English Name: **Orchardgrass - Sheep-sorrel Herbaceous Vegetation**
NVC Scientific Name: ***Dactylis glomerata - Rumex acetosella* Herbaceous Vegetation**
NVC Identifier: **CEGL006107**

LOCAL INFORMATION

Environmental Description: These early-successional communities are found throughout Fort Necessity National Battlefield in mowed fields and former pastures, orchards and agricultural areas. They are widely variable, ranging from grasslands to tall shrublands or woodlands. Species composition varies considerably with differing soil edaphic and moisture characteristics of each site. Land-use history varies greatly among delineated communities as well, and some of these areas may be mowed periodically. flat-top goldenrod not listed in Appendix C in FONE.
Vegetation Description: A scattered tree canopy (<20m in height) may be present, covering less than 30% of the area. Black cherry (*Prunus serotina*), paradise apple (*Malus pumila*) and fanleaf hawthorn (*Crataegus flabellata*) are often found scattered throughout these communities. A tall shrub layer (2–6m in height) may cover up to 80% of the community, composed of Morrow's honeysuckle (*Lonicera morrowii*), southern arrowwood (*Viburnum dentatum* var. *lucidum*), fanleaf hawthorn, and sweet crabapple (*Malus coronaria*). The short shrub layer (0–2m in height) typically covers approximately 20% of the area, however the percent cover can vary between 1 and 85%. Common shrub species include: Morrow's honeysuckle, southern arrowwood, black cherry, hawthorns (*Crataegus* spp.), dogwoods (*Cornus* spp.), serviceberries (*Amelanchier* spp.), Blue Ridge blueberry (*Vaccinium pallidum*), northern dewberry (*Rubus flagellaris*), bristly dewberry (*Rubus hispidus*), and Allegheny blackberry (*Rubus allegheniensis*). These communities typically contain a dense graminoid and herbaceous layer that covers approximately 85% of the area, although the percent cover can vary between 10 and 100%. The matrix of the graminoid-herbaceous layer is composed of goldenrods and various graminoids, such as wrinkleleaf goldenrod (*Solidago rugosa*), early goldenrod (*Solidago juncea*), flat-top goldenrod (*Euthamia graminifolia*), creeping bentgrass (*Agrostis stolonifera*), sedges (*Carex* spp.), flattened oatgrass (*Danthonia compressa*), sweet vernalgrass (*Anthoxanthum odoratum*), deertongue (*Dichanthelium clandestinum*), common velvetgrass (*Holcus lanatus*), and panicgrasses (*Panicum* spp.). Other common species include: common cinquefoil (*Potentilla simplex*), common yarrow (*Achillea millefolium*), Queen Anne's lace (*Daucus carota*), golden ragwort (*Packera aurea*), Canada goldenrod (*Solidago canadensis* var. *scabra*), common selfheal (*Prunella vulgaris*), timothy (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), bluegrass (*Poa* spp.), common yellow oxalis (*Oxalis stricta*), narrowleaf mountainmint (*Pycnanthenum tenuifolium*), orchardgrass (*Dactylis glomerata*), broomsedge bluestem (*Andropogon virginicus*), Gray goldenrod (*Solidago nemoralis*) and giant goldenrod (*Solidago gigantea*). Seasonal variation results in distinct changes in species composition. Early in the growing season, graminoid species will dominate the herbaceous layer, whereas later in the growing season, goldenrods will be dominant. Vines such as eastern poison ivy (*Toxicodendron radicans*) and greenbriar (*Smilax glauca, S. rotundifolia*) may cover up to 20% of the old field community. These communities are prone to invasion by exotic species, primarily Morrow's honeysuckle, multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*) and purple crownvetch (*Coronilla varia*).

Most Abundant Species:

Stratum	Lifeform	Species
Tree canopy	Broad-leaved deciduous tree	*Prunus serotina, Malus* spp., *Crataegus* spp.
Tall shrub/sapling	Broad-leaved deciduous shrub	*Crataegus* spp., *Lonicera morrowii, Viburnum dentatum* var. *lucidum, Malus* spp.
Short shrub/sapling	Broad-leaved deciduous shrub	*Lonicera morrowii, Crataegus* spp., *Malus* spp., *Cornus* spp., *Rubus* spp.
Herb (field)	Forb	*Solidago rugosa, Solidago juncea, Euthamia graminifolia*
Herb (field)	Graminoid	*Agrostis stolonifera, Carex* spp., *Danthonia compressa, Anthoxanthum odoratum, Panicum clandestinum, Holcus lanatus*

Characteristic Species: *Solidago rugosa, Solidago juncea, Euthamia graminifolia, Agrostis stolonifera, Carex* spp., *Danthonia compressa, Anthoxanthum odoratum, Panicum clandestinum, Holcus lanatus, Lonicera morrowii, Crataegus* spp., *Malus* spp., *Cornus* spp., *Rubus* spp.
Other Noteworthy Species: Information not available.
Local Range: This common association is found throughout the main unit of Fort Necessity National Battlefield.
Classification Comments: Successional Old Fields are distinguished from other types by the dominance of goldenrods and grasses, often with thick tall or short shrub layers containing *Lonicera morrowii, Crataegus* spp., *Malus* spp., *Cornus* spp., *Rubus* spp.
Other Comments: None.
Local Description Authors: S. J. Perles (PNHP).
Plots: FONE.4, FONE.11, FONE.19, FONE.20, FONE.32, FONE.33, FONE.37, FONE.38, FONE.39, FONE.41. FONE.42.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Herbaceous Vegetation (V)
Physiognomic Subclass	Perennial graminoid vegetation (V.A.)
Physiognomic Group	Temperate or subpolar grassland (V.A.5.)
Physiognomic Subgroup	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
Formation	Medium-tall sod temperate or subpolar grassland (V.A.5.N.c.)
Alliance	*Dactylis glomerata* - *Rumex acetosella* Herbaceous Alliance (A.1190)
Alliance (English name)	Orchardgrass - Sheep-sorrel Herbaceous Alliance
Association	*Dactylis glomerata* - *Rumex acetosella* Herbaceous Vegetation
Association (English name)	Orchardgrass - Sheep-sorrel Herbaceous Vegetation
Association (Common name)	Orchardgrass Pasture
Ecological System(s):	Information not available

GLOBAL DESCRIPTION

Concept Summary: This broadly defined vegetation type includes pasture and post-agricultural fields and is largely composed of nonnative grasses and herbs in the early stages of succession (generally of European origin). Physiognomically, these grasslands are generally comprised of mid-height (1–3 feet tall) grasses and forbs, with occasional scattered shrubs. Species composition varies from site to site, depending on land-use history and perhaps soil type, but in general, this vegetation is quite wide-ranging in northeastern and midwestern states, and at higher elevations (610–1220 m [2000–4000 feet]) in the southeastern states. In addition to the nominal species, other associates may include *Phleum pratense, Lolium perenne, Agrostis hyemalis, Elymus repens, Oxalis stricta, Schizachyrium scoparium, Achillea millefolium, Asclepias syriaca, Chenopodium album, Bromus tectorum, Bromus inermis,* and many others.
Environmental Description: Information not available.
Vegetation Description: In addition to *Dactylis glomerata* and *Rumex acetosella* these grassy fields are characterized by *Symphyotrichum* spp. (including *Symphyotrichum lateriflorum* var. *lateriflorum* and *Symphyotrichum novae-angliae), Rudbeckia hirta, Pteridium aquilinum, Chenopodium album, Asclepias syriaca, Andropogon virginicus, Schizachyrium scoparium, Phytolacca americana, Phleum pratense, Poa pratensis, Poa compressa, Elymus repens, Bromus inermis, Solidago* spp. (including *Solidago rugosa, Solidago nemoralis, Solidago juncea, Solidago canadensis, Solidago canadensis* var. *scabra), Euthamia graminifolia, Oenothera biennis, Potentilla simplex, Daucus carota, Ambrosia artemisiifolia, Hieracium* spp., *Taraxacum officinale, Vicia cracca, Trifolium* spp., and many others.
Most Abundant Species: Information not available.
Characteristic Species: Information not available.
Other Noteworthy Species: Information not available.
USFWS Wetland System: None.

DISTRIBUTION

Range: This vegetation is quite wide-ranging in northeastern and midwestern states, and possibly occurs at higher elevations in the southeastern states.
States/Provinces: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, TN, VA, VT, WV.
Federal Lands: NPS (Cape Cod, Cumberland Gap, Fort Necessity, Johnstown Flood, Morristown).

CONSERVATION STATUS

Rank: GNA (invasive) (28-Jan-2002).
Reasons: This vegetation type includes pasture and post-agricultural fields, and is largely composed of nonnative grasses and herbs (generally of European origin).

CLASSIFICATION INFORMATION

Status: Standard.
Confidence: 3 – Weak.
Comments: None.
Similar Associations:
Dactylis glomerata - Solidago spp. Herbaceous Vegetation (CEGL006517).
Lolium (arundinaceum, pratense) Herbaceous Vegetation (CEGL004048).
Phleum pratense - Bromus pubescens - Helenium autumnale Herbaceous Vegetation (CEGL004018).
Related Concepts: Information not available.

SOURCES
Description Authors: L. Sneddon.
References: Eastern Ecology Working Group n.d.

Figure 19. Successional Old Field at the Main Unit of Fort Necessity National Battlefield (plot FONE.19). July 2003. NAD 1983 / UTM easting 620802, northing 4408235.

Figure 20. Successional Old Field at the Main Unit of Fort Necessity National Battlefield (plot FONE.42). September 2003. NAD 1983 / UTM easting 621870, northing 4407699.

COMMON NAME (PARK-SPECIFIC): WET MEADOW

SYNONYMS
NVC English Name: **Tussock Sedge - Inflated Sedge Herbaceous Vegetation**
NVC Scientific Name: ***Carex stricta* - *Carex vesicaria* Herbaceous Vegetation**
NVC Identifier: **CEGL006412**

LOCAL INFORMATION

Environmental Description: This community is found in low-lying areas of Fort Necessity National Battlefield where the ground is seasonally saturated with water. As with the Successional Old Fields, the Wet Meadows may be mowed periodically by park managers.
Vegetation Description: Woody species are sparse to absent in this community, with low shrubs typically covering less than 30% of the area. White meadowsweet (*Spiraea alba*) and bristly dewberry (*Rubus hispidus*) are commonly occurring shrubs. This community is composed of predominantly hydrophilic species that form a thick herbaceous layer covering nearly 100% of the area. Tussock sedge (*Carex stricta*), wrinkleleaf goldenrod (*Solidago rugosa*), creeping bentgrass (*Agrostis stolonifera*), sedges (*Carex* spp.), spikerush (*Eleocharis* spp.), flat-top goldenrod (*Euthamia graminifolia*), rice cutgrass (*Leersia oryzoides*) and common rush (*Juncus effusus*) are the dominant species. Other common species include: asters (*Aster* spp.), green bulrush (*Scirpus atrovirens*), swamp verbena (*Verbena hastata*), purpleleaf willowherb (*Epilobium coloratum*), sensitive fern (*Onoclea sensibilis*), sweet woodreed (*Cinna arundinacea*) and Canada goldenrod (*Solidago canadensis* var. *scabra*). Many graminoid and herbaceous species associated with the successional old field communities can be found in low abundance in the wet meadow. Seasonal variation results in distinct changes in species composition.
Most Abundant Species:

Stratum	Lifeform	Species
Short shrub/sapling	Broad-leaved deciduous shrub	*Spiraea alba, Rubus hispidus*
Herb (field)	Forb	*Solidago rugosa, Euthamia graminifolia*
Herb (field)	Graminoid	*Carex stricta, Agrostis stolonifera, Carex* spp., *Eleocharis* spp.

Characteristic Species: *Carex stricta, Carex* spp., *Eleocharis* spp., *Solidago rugosa, Spiraea alba, Verbena hastata, Epilobium coloratum, Onoclea sensibilis, Cinna arundinacea*.
Other Noteworthy Species: Information not available.
Local Range: This community is associated with Great Meadow Run and the Great Meadows areas of Fort Necessity National Battlefield.
Classification Comments: This community is distinguished from the Successional Old Field by the presence of saturated or poorly drained soils and abundant hydrophilic species.
Other Comments: None.
Local Description Authors: S. J. Perles (PNHP).
Plots: FONE.21, FONE.22, FONE.35, FONE.36.

GLOBAL INFORMATION

NVC CLASSIFICATION

Physiognomic Class	Herbaceous Vegetation (V)
Physiognomic Subclass	Perennial graminoid vegetation (V.A.)
Physiognomic Group	Temperate or subpolar grassland (V.A.5.)
Physiognomic Subgroup	Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
Formation	Seasonally flooded temperate or subpolar grassland (V.A.5.N.k.)
Alliance	*Carex stricta* Seasonally Flooded Herbaceous Alliance (A.1397)
Alliance (English name)	Tussock Sedge Seasonally Flooded Herbaceous Alliance
Association	*Carex stricta* - *Carex vesicaria* Herbaceous Vegetation
Association (English name)	Tussock Sedge - Inflated Sedge Herbaceous Vegetation
Association (Common name)	Eastern Tussock Sedge Meadow
Ecological System(s):	Laurentian-Acadian Wet Meadow-Shrub Swamp (CES201.582)

GLOBAL DESCRIPTION

Concept Summary: These tussock sedge meadows are distributed across the northeastern United States. They occur in seasonally flooded basins or on stream or lake margins. The substrate is peat or muck of variable depth overlying mineral soil. Standing water may be present only at the beginning of, or through much of, the growing season depending on the site and the year's precipitation; even when the water drops, the soils remain saturated. Microtopography is characterized by large tussocks, particularly when the hydroperiod is extended. The physiognomy is strongly herbaceous, or in some cases herbs mixed with shrubs (up to 25% shrub cover); trees are absent. Bryophyte cover is usually sparse, but may occasionally reach over 50%. *Carex stricta*, in its tussock form, is the usual dominant. *Carex vesicaria, Carex utriculata*, and *Calamagrostis canadensis* may also be locally abundant. Associated graminoids include *Carex canescens, Carex comosa, Carex scoparia, Carex stipata, Carex vulpinoidea, Glyceria canadensis, Dulichium arundinaceum, Leersia oryzoides*, and *Scirpus cyperinus*; forbs and ferns include *Asclepias incarnata, Thelypteris palustris, Eupatorium maculatum, Campanula aparinoides, Osmunda regalis, Comarum palustre, Lysimachia terrestris, Angelica atropurpurea, Eupatorium perfoliatum, Lycopus americanus, Galium obtusum*, and others. *Lythrum salicaria* may be invasive in some settings. Shrub associates vary with geography. In the northern part of the range, *Alnus incana, Myrica gale, Ilex verticillata, Chamaedaphne calyculata*, and *Spiraea alba* are often present. Bryophytes, where present, include *Sphagnum magellanicum, Sphagnum girgensohnii, Sphagnum palustre, Drepanocladus aduncus*, and others. This association is differentiated from other wet meadows by the strong dominance of *Carex stricta*.

Environmental Description: These tussock sedge meadows are distributed across the northeastern United States. They occur in seasonally flooded basins or on stream or lake margins. The substrate is peat or muck of variable depth overlying mineral soil. Standing water may be present only at the beginning of, or through much of, the growing season depending on the site and the year's precipitation; even when the water drops, the soils remain saturated. Microtopography is characterized by large tussocks, particularly when the hydroperiod is extended.

Vegetation Description: The physiognomy is strongly herbaceous, or in some cases herbs mixed with shrubs (up to 25% shrub cover); trees are absent. Bryophyte cover is usually sparse

but may occasionally reach over 50%. *Carex stricta*, in its tussock form, is the usual dominant. *Carex vesicaria, Carex utriculata*, and *Calamagrostis canadensis* may also be locally abundant. Associated graminoids include *Carex canescens, Carex comosa, Carex scoparia, Carex stipata, Carex vulpinoidea, Glyceria canadensis, Dulichium arundinaceum, Leersia oryzoides*, and *Scirpus cyperinus*; forbs and ferns include *Asclepias incarnata, Thelypteris palustris, Eupatorium maculatum, Campanula aparinoides, Osmunda regalis, Comarum palustre, Lysimachia terrestris, Angelica atropurpurea, Eupatorium perfoliatum, Lycopus americanus, Galium obtusum*, and others. *Lythrum salicaria* may be invasive in some settings. Shrub associates vary with geography. In the northern part of the range, *Alnus incana, Myrica gale, Ilex verticillata, Chamaedaphne calyculata*, and *Spiraea alba* are often present. Bryophytes, where present, include *Sphagnum magellanicum, Sphagnum girgensohnii, Sphagnum palustre, Drepanocladus aduncus*, and others.
Most Abundant Species: Information not available.
Characteristic Species: Information not available.
Other Noteworthy Species: *Scirpus ancistrochaetus.*
USFWS Wetland System: Palustrine.

DISTRIBUTION
Range: This tussock sedge meadow is found in northern New England, the Adirondack Mountains, and parts of the Appalachians.
States/Provinces: CT, DE, MA, MD, ME:S3, NH, NJ, NY:S4, PA, RI, VT:S4, WV.
Federal Lands: NPS (Acadia, Fort Necessity); USFWS (Great Swamp).

CONSERVATION STATUS
Rank: GNR (29-Aug-2000).
Reasons: Information not available.

CLASSIFICATION INFORMATION
Status: Standard.
Confidence: 2 – Moderate.
Comments: Information not available.
Similar Associations:
Calamagrostis canadensis - *Scirpus* spp. - *Dulichium arundinaceum* Herbaceous Vegetation (CEGL006519)
Carex stricta - *Carex* spp. Herbaceous Vegetation (CEGL002258)
Related Concepts:
Carex stricta wet meadow (CAP pers. comm. 1998) ?
Coastal Plain Intermittent Pond (Breden 1989) B
Palustrine Persistent Emergent Wetland (PEM1) (Cowardin et al. 1979) ?
Sedge Meadow (Thompson 1996) ?
Southern New England nutrient-poor streamside/lakeside marsh (Rawinski 1984) ?
Southern New England nutrient-rich streamside/lakeside marsh (Rawinski 1984) ?
Tussock sedge meadow (NAP pers. comm. 1998) ?

SOURCES
Description Authors: S. C. Gawler.
References: Breden 1989, Breden et al. 2001, CAP pers. comm. 1998, Cowardin et al. 1979, Curtis 1959, Eastern Ecology Working Group n.d., Edinger et al. 2002, Fike 1999, Gawler 2002, Metzler and Barrett 2001, NAP pers. comm. 1998, Northern Appalachian Ecology Working

Group 2000, Rawinski 1984, Sperduto 2000b, Swain and Kearsley 2001, Thompson 1996, Thompson and Sorenson 2000.

Figure 21. Wet Meadow at the Main Unit of Fort Necessity National Battlefield (plot FONE.22). July 2003. NAD 1983 / UTM easting 621280, northing 4408169.

Figure 22. Wet Meadow at the Main Unit of Fort Necessity National Battlefield (plot FONE.35). August 2003. NAD 1983 / UTM easting 620665, northing 4408558.

Vegetation Map Production

In order to produce an association-level vegetation map, the formation-level vegetation map was edited and refined onscreen in ArcView 3.2. Based on the data analyses, each polygon was assigned one of the eight vegetation associations. The vegetation types were assigned using information from plot data, field observations, aerial photography signatures, and topographic maps. Polygon boundaries were also revised based on these four information sources. Polygons that were attributed with modified Anderson level II categories retained their attributes. An aerial photograph interpretation key for the vegetation associations is located in Appendix A. However, some associations could not be distinguished reliably by aerial photography signatures alone. These associations included three hardwood forest types, Tuliptree Forest, White Oak – Mixed Hardwood Forest and Northern Red Oak – Mixed Hardwood Forest, and two herbaceous types, Successional Old Field and Wet Meadow. In these circumstances, plot data, field observations and topographic maps were relied upon to inform the polygon delineation and association name assignments.

The thematic accuracy of this vegetation association map was then assessed. Based on the accuracy assessment sampling points, the association-level map was revised again to correct errors and create more accurate vegetation association polygon boundaries. In this final revision, accuracy assessment data, plot data, field observations, aerial photography signatures, and topographic maps were used to revise polygon boundaries and attributes. The resulting final vegetation association map is shown in Figure 23 and summary information on the vegetation associations is provided in Table 5. The number of total mapped hectares listed in Table 5 is larger than the number of mapped hectares within the park boundary because some of the mapped polygons extend beyond the park boundary. Metadata for the vegetation association shapefile, the plot location and accuracy assessment sampling point location shapefiles, the digital photomosaic, and the PLOTS database were prepared according to Federal Geographic Data Committee standards and have been provided as a deliverable along with this report.

Accuracy Assessment

Positional Accuracy

The final horizontal positional accuracy for the mosaic is 1.19 meters and meets Class 1 National Map Accuracy Standards (FGDC 1998b; Minnesota Governor's Council on Geographic Information and Minnesota Land Management Information Center 1999). A copy of the spreadsheet that contains the x and y coordinates for each ground control point and the root mean square error accuracy calculation formula is included in the air photo archive at the North Carolina State University Center for Earth Observation.

Thematic Accuracy

Based on the contingency matrix (Table 6), the Kappa index for the vegetation association map was 64.8% ± 10.2%, with the overall percent accuracy calculated as 69.8%. The majority of this error can be attributed to misclassification of three hardwood types: Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, and Tuliptree Forest. Three

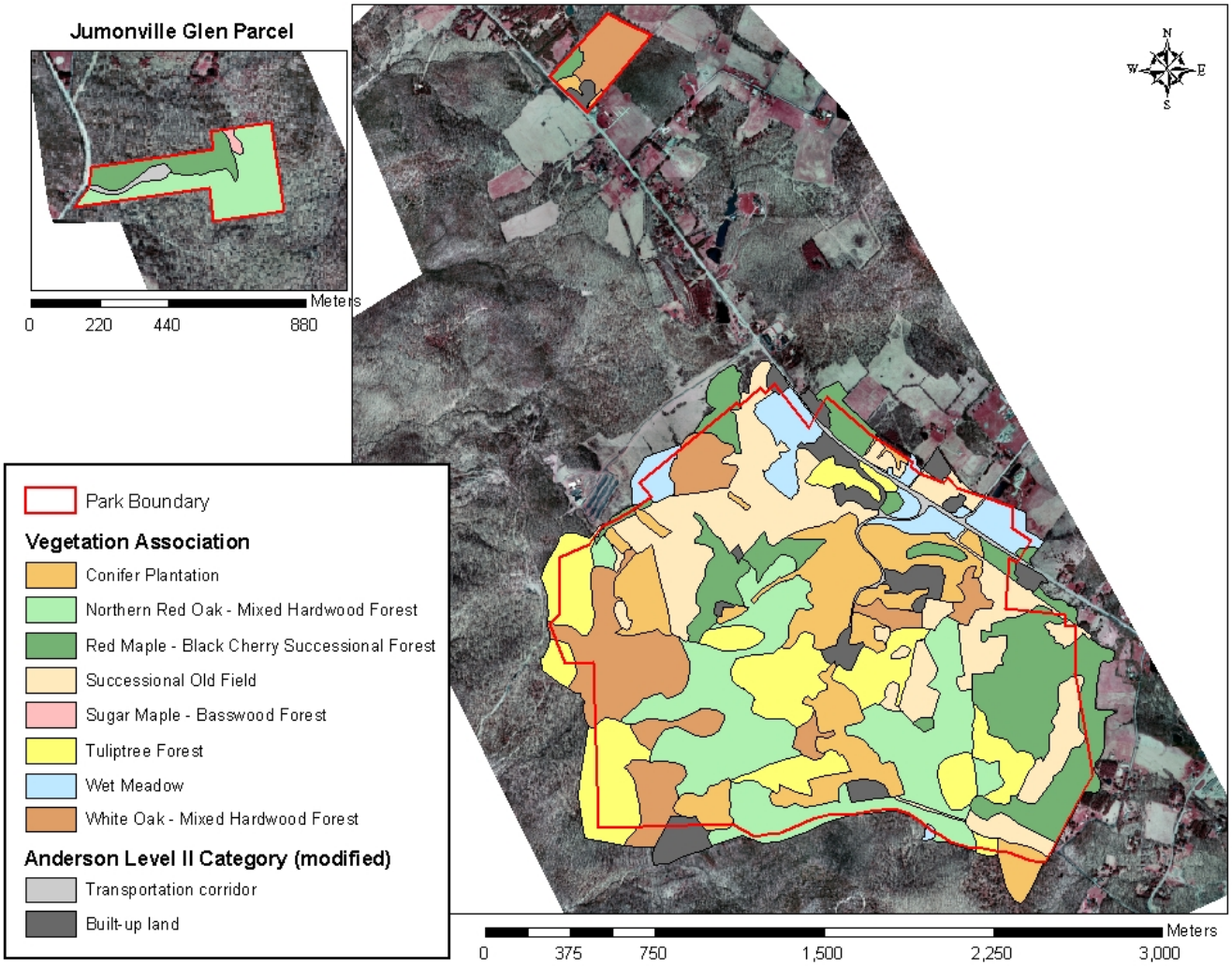

Figure 23. Vegetation associations and Anderson level II categories (modified) of Fort Necessity National Battlefield.

Table 5. Number of polygons, total mapped hectares, and hectares mapped within the park boundary for the vegetation associations and Anderson level II categories (modified) at Fort Necessity National Battlefield.

	Number of Polygons	Total Mapped Hectares	Mapped Hectares within Park Boundary
Vegetation Association			
Conifer Plantation	16	56.26	53.07
Northern Red Oak - Mixed Hardwood Forest	6	75.98	73.05
Red Maple - Black Cherry Successional Forest	14	62.35	50.30
Successional Old Field	14	68.05	64.06
Sugar Maple - Basswood Forest	1	0.27	0.27
Tuliptree Forest	12	62.15	52.59
Wet Meadow	8	20.54	16.36
White Oak - Mixed Hardwood Forest	8	49.90	46.33
Anderson Level II Categories (modified)			
Built-up land	13	20.06	13.45
Transportation corridor	2	4.04	3.73
Total	94	419.61	373.22

Table 6. Contingency matrix and calculated errors for the thematic accuracy assessment of the vegetation association map of Fort Necessity National Battlefield.

Accuracy Assessment Observation	Mapped Vegetation Association								Total	Error of Commission (Percent Correct)
	Conifer Plantation	Red Maple - Black Cherry Successional Forest	Northern Red Oak - Mixed Hardwood Forest	Successional Old Field	Sugar Maple Basswood Forest	Tuliptree Forest	Wet Meadow	White Oak - Mixed Hardwood Forest		
Conifer Plantation	10	1							11	90.9%
Red Maple - Black Cherry Successional Forest		9	1			1		1	12	75.0%
Northern Red Oak - Mixed Hardwood Forest			4		1	2		2	9	44.4%
Successional Old Field				9					9	100.0%
Sugar Maple Basswood Forest									0	N/A
Tuliptree Forest			3			3			6	50.0%
Wet Meadow				1			5		6	83.3%
White Oak - Mixed Hardwood Forest			2			4		4	10	40.0%
Total	10	10	10	10	1	10	5	7	63	
Error of Omission (Percent Correct)	100.0%	90.0%	40.0%	90.0%	N/A	30.0%	100.0%	57.1%		

Total Points Correct	44
Overall Accuracy	69.8%
Kappa Index	64.8%
90% confidence interval for Kappa Index	10.7%

Table 7. Contingency matrix and calculated errors for the thematic accuracy assessment of the vegetation association map of Fort Necessity National Battlefield with three hardwood forest types lumped.

	Mapped Vegetation Association							
Accuracy Assessment Observation	Conifer Plantation	Red Maple - Black Cherry Successional Forest	Successional Old Field	Sugar Maple - Basswood Forest	Wet Meadow	White Oak + Northern Red Oak + Tuliptree Forest	Total	Error of Commission (Percent Correct)
Conifer Plantation	10	1					11	90.9%
Red Maple - Black Cherry Successional Forest		9				3	12	75.0%
Successional Old Field			9				9	100.0%
Sugar Maple - Basswood Forest							0	N/A
Wet Meadow			1		5		6	83.3%
White Oak + Northern Red Oak + Tuliptree Forest				1		24	25	96.0%
Total	10	10	10	1	5	7	63	
Error of Omission (Percent Correct)	100.0%	90.0%	90.0%	N/A	100.0%	88.9%		
							Total Points Correct	57
							Overall Accuracy	90.5%
							Kappa Index	87.2%
							90% confidence interval for Kappa Index	7.7%

associations, Conifer Plantation, Wet Meadow, and Successional Old Field, meet the USGS/NPS vegetation mapping protocol requirement of 80% accuracy. Red Maple – Black Cherry Successional Forest nearly meets the requirement with 90% error of omission and 75% error of commission. Error could not be calculated for Sugar Maple – Basswood Forest because no accuracy assessment point fell within the one small polygon of this forest type. The accuracy point assigned to that polygon was actually located in Northern Red Oak – Mixed Hardwood Forest, and the polygon boundary was revised accordingly.

The calculated error for three hardwood associations, Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, and Tuliptree Forest, fell well below 60% (Table 6). When these three associations were lumped together in the thematic accuracy assessment, the calculated error exceeded 80% (Table 7). With the three hardwood forest types lumped, the Kappa index for the entire map equalled 87.2% ± 7.7% and the overall percent accuracy was 90.5%. The dramatic increase in Kappa index and overall percent accuracy between Tables 6 and 7 illustrates that the much of mapping error can attributed to difficulties in accurately mapping the hardwood forest types. This difficulty is expected given the type of aerial photography and the mapping protocol used in this project.

Project Deliverables

Final products of the vegetation mapping project are shown in Table 8. All products have been delivered to the National Park Service by the Pennsylvania Science Office of The Nature Conservancy with this report.

Table 8. Summary of products resulting from the Fort Necessity National Battlefield vegetation classification and mapping project.

Product	FGCD-complaint spatial metadata
Aerial photos, including flight line map and photoindex	Yes
Photomosaic as paper copy and in digital format	Yes
Annotated field forms with vegetation plot sampling data	Not applicable
Vegetation plot sampling data in the PLOTS 2.0 database	Not applicable
Differentially corrected GPS locations of vegetation plots	Yes
Annotated field forms with thematic accuracy assessment data	Not applicable
Thematic accuracy assessment data in the PLOTS 2.0 database	Not applicable
Differentially corrected GPS locations of thematic accuracy assessment sampling points	Yes
Digital photos representative of all vegetation types	Not applicable
Final map of vegetation associations as paper copy and in digital format	Yes
Final report as paper copy and in digital format	Not applicable

Discussion

Vegetation Classification and Characterization

This study of Fort Necessity National Battlefield identified eight vegetation associations: Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, Sugar Maple – Basswood Forest, Tuliptree Forest, Red Maple – Black Cherry Successional Forest, Conifer Plantation, Successional Old Field, and Wet Meadow. These associations reflect the land use history, ongoing management, and varied environmental settings of the park.

The Successional Old Field and Wet Meadow associations in the Main Unit of Fort Necessity National Battlefield are important cultural and natural resources. In particular, the Great Meadows and surrounding fields which contain these two associations provide visitors with landscape context for the historical battles that took place and are managed to maintain the historic landscape surrounding the fort. The most significant management concern for these associations is the growth of woody species, especially invasive exotic woody species such as honeysuckles (*Lonicera* spp.). Several of the fields in and adjacent to the Great Meadows are currently undergoing natural succession with the growth of native woody species, predominantly black cherry (*Prunus serotina*), hawthorns (*Crataegus* spp.), and southern arrowwood (*Viburnum dentatum* var. *lucidum*), and exotic woody species, predominantly Morrow's honeysuckle (*Lonicera morrowii*). Without management of the woody species, these fields will succeed into Red Maple – Black Cherry Successional Forest in the next decade.

Morrow's honeysuckle, an invasive exotic shrub, is of particular concern due to its capacity to produce large numbers of seeds that are easily dispersed by birds. Morrow's honeysuckle was removed from an eight-ha (20-ac) area around the fort site in 2003 and 2004. Additionally, experimental honeysuckle-removal plots were established in 2003 in the fields to the southwest of the Great Meadows to restore habitat for the American woodcock (*Scolopax minor*). A combination of mowing and brush hogging should be used in open areas or areas recently treated for honeysuckle removal in order to suppress honeysuckle regeneration and the growth of woody species. Additional areas can be targeted for honeysuckle removal with a combination of mechanical control and selective herbicide application. Effective mechanical control includes removal of the entire shrub and root system with tractors or repeated clipping of smaller shrubs during the growing season over a period of three- to five-years. The selective application of herbicides as foliar sprays or to cut-stumps may be necessary to prevent resprouting (Batcher and Stiles 2001).

Several other invasive species are problematic in the Successional Old Field and Wet Meadow associations, including purple crownvetch (*Coronilla varia*), multiflora rose (*Rosa multiflora*), teasel (*Dipsacus sylvestris*), bull thistle (*Cirsium vulgare*), and Canadian thistle (*Cirsium arvense*). Management and monitoring for these species is critical to maintain the diverse native species composition of the fields and retain their historical open nature.

The Successional Old Field and Wet Meadow associations provide habitat to numerous species of birds, as well as moths, butterflies, and dragonflies. In sufficiently large areas, these early successional vegetation types are excellent habitat for American woodcock, golden-winged

warbler (*Vermivora chrysoptera*), prairie warbler (*Dendroica discolor*), yellow-breasted chat (*Icteria virens*), field sparrow (*Spizella pusilla*), red-winged blackbird (*Agelaius phoeniceus*), eastern meadowlark (*Sturnella magna*), and American kestrel (*Falco sparverius*) (Yahner et al. 2004). Succession of these fields to dense shrubland and forest will decrease the available habitat for these bird species. Numerous native and state-listed rare species of Lepidoptera and Odonata are dependent on Successional Old Field and Wet Meadow habitats for parts of their life history. Three state-listed species, black dash (*Euphyes conspicuous*), aphrodite fritillary (*Speyeria aphrodite*), and Halloween pennant (*Celithemis eponina*), have been documented from the Great Meadows (Ranson 1998). Other documented native Lepidoptera include eastern tailed-blue (*Cupido (Everes) comyntas*), meadow fritillary (*Boloria bellona*), pearl crescent (*Phyciodes tharos*), great spangled fritillary (*Speyeria cybele*), clouded sulphur (*Colias philodice*), yellow-collared scapemoth (*Cisseps fulvicollis*), Virginia ctenuchid moth (*Ctenucha virginica*), and forage looper (*Caenurgina erechtea*) (Ranson 1998). Several Odonata species documented from the Great Meadows that rely largely on old field habitats for foraging include calico pennant (*Celithemis elisa*) and twelve-spotted skimmer (*Libellula pulchella*) (Ranson 1998).

Historically, the majority of the Great Meadows vegetation was similar to a Wet Meadow instead of the Successional Old Field that exists currently. The installation of drain tiles in the meadow and the channelization of Great Meadow Run and Indian Run have altered the hydrology of the meadow, creating a dry old field community where wet meadow previously existed. The removal of the drain tiles and restoration of the stream channels to a more natural meandering pattern would promote the reestablishment of wet meadow vegetation. Currently, only approximately 20 ha (49 ac) of wet meadow exist in the park, all associated with Great Meadow Run.

The Wet Meadow association is a palustrine vegetation type that can be crosswalked to the Cowardin classification system that was used for the National Wetland Inventory mapping efforts (Cowardin et al. 1979). Wet Meadow can be crosswalked to Palustrine, Emergent, Persistent (PEM1).

Red Maple – Black Cherry Successional Forest is a common vegetation association in Fort Necessity National Battlefield that is heavily influenced by land use history. This variable vegetation type is a result of past agricultural and silvicultural activities that occurred prior to the park's establishment in 1974. These stands occur predominantly on former agricultural land that was abandoned in the last 25 years and has developed into forest through natural sucession, as seen in the eastern portion of the park's Main Unit. In addition, Red Maple – Black Cherry Successional Forest may be found on sites from which the formerly dominant oaks (*Quercus* spp.) have been harvested. The Red Maple – Black Cherry Successional Forest stand in the Jumonville Glen Unit may have developed in this manner. This assocation can also develop in conifer plantations that have been heavily thinned. Because Red Maple – Black Cherry Successional Forest stands are characterized by early successional species that have established following relatively recent disturbances, nonnative invasive species, including Morrow's honeysuckle, multiflora rose, and Japanese barberry (*Berberis thunbergii*), often compose a high percent of the groundstory cover.

In the 1930s and 1950s, several conifer plantations were established in the Main Unit of Fort Necessity National Battlefield prior to the establishment of the park. Red pine (*Pinus resinosa*), white pine (*Pinus strobus*), Norway spruce (*Picea abies*), and Japanese larch (*Larix kaempferi*) were commonly planted in these stands. The vegetation analysis detected a wide range of variability in the current conifer plantations due to the variability in edaphic characteristics of the sites, the degree of management or disturbance, and the type of conifer planted. In the past ten years, ice-storm damage and silvicultural thinning have created variation in vegetation structure and species composition. Canopy openings have allowed adventitious hardwoods to establish in several plantations, creating mixed hardwood-conifer stands. The composition of the adventitious hardwood species differs considerably due to the edaphic characteristics of the site, the degree of management or disturbance, and the type of conifer planted. The disturbance from the silvicultural treatments and the fragmented nature of the park leave these associations prone to invasion by exotic species, including Morrow's honeysuckle, multiflora rose, and Japanese barberry.

The Sugar Maple – Basswood Forest is restricted to a small area of Jumonville Glen where the underlying limestone geology has contributed to the establishment and growth of plant species that require rich soil conditions. This association occurs on a flat lowlying area over calcareous bedrock that likely contains some limestone. The weathering of the underlying bedrock creates rich soils that favor the dominance of sugar maple (*Acer saccharum*) and basswood (*Tilia americana*). The actual size of the Sugar Maple – Basswood Forest stand may be larger than the small area that occurs on park property.

The high rate of error in mapping Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, and Tuliptree Forest can be attributed to the diverse topography and land use history of the southwestern corner of the park's Main Unit. The rolling topography creates frequent variation in slope and aspect, as well as microclimates in hollows and on hilltops. Despite the tendency for white oak to be found on upper slopes and for northern red oak and tuliptree to be found on lower slopes, the forest associations do not always sort strictly by topography. The composition of the forests in this area is further confounded by past land use history, including silvicultural, grazing, and park resource management activities. For example, one hilltop in the Main Unit currently supports Tuliptree Forest, despite its high elevation. These trees were likely planted in the 1980s as part of a deer exclosure experiment in the park. Historic natural disturbances can also be observed in the current forest associations. Stumps of American chestnut (*Castanea dentata*) cut during the chestnut blight of the 1930s persist in these three forest associations.

The variability in topography in the forested sections of Fort Necessity National Battlefield does provide habitat for a diverse mix of bird species. Typical northern species such as solitary vireo (*Vireo solitarius*), magnolia warbler (*Dendroica magnolia*), blackburnian warbler (*Dendroica fusca*), and golden-crowned kinglet (*Regulus satrapa*) are found in the park, along with typical southern species such as red-bellied woodpecker (*Melanerpes carolinus*), Carolina chickadee (*Poecile carolinensis*), blue-gray gnatchatcher (*Polioptila caerulea*), and white-eyed vireo (*Vireo griseus*) (Yahner et al. 2004).

Nonnative invasive plant species pose a prominent threat to the forest associations in Fort Necessity National Battlefield. Japanese barberry (*Berberis thunbergii*) is the most widespread

nonnative invasive species in park forests. Japanese barberry is shade tolerant and unpalatable to deer, making it a successful colonist in forests. Manual removal with gloves, hoe, weed wrench, or mattock is an effective removal technique for Japanese barberry. Complete removal of the root system renders herbicide application unnecessary (Brunelle and Lapin 1996). Multiflora rose (*Rosa multiflora*) and Japanese stilt grass (*Microstegium vimineum*) are two additional common forest invasives in Fort Necessity National Battlefield. Cutting, followed by direct herbicide application to the cut stem seems to be the most effective method of multiflora rose control in forest settings. In open fields, mechanical control, similar to that described above for honeysuckle, also can be effective against multiflora rose (Eckardt 1987). For Japanese stilt grass, hand pulling in late summer is the preferred method for removing small populations, however, this method is labor and time intensive. The application of herbicide may be the only viable option for controlling large populations of Japanese stilt grass. Selective herbicides such as imazameth are recommended to reduce the impact on surrounding native vegetation (Tu 2000).

The second prominent threat to the park's forest associations is the suppression of oak regeneration by the abundance of white-tailed deer and the absence of catastrophic disturbances that originally facilitated the establishment of oak-dominated forests. This trend is widespread throughout the forests of Pennsylvania and is not unique to Fort Necessity National Battlefield. Due to decreased hunting pressure, the absence of sufficient predators, plentiful food sources in suburban and agricultural areas, and other contributing factors, deer in Pennsylvania have become abundant. The grazing pressure on tree seedlings exerted by large numbers of deer inhibits regeneration of some tree species and alters the species composition of the regenerating forest from oak (*Quercus* spp.) species to red maple (*Acer rubrum*) and black cherry (*Prunus serotina*). All tree species experience increased seedling mortality from deer browse; however, red maple and black cherry seedlings are considerably less palatable to deer than oak seedlings. As a result, red maple and black cherry seedlings have a greater chance of becoming saplings and canopy trees. The absence of disturbances such as logging and fire also contribute to this shift in species composition (Mikan et al. 1994; Orwig and Abrams 1999). Red maple and sugar maple (*Acer saccharum*) seedlings are more tolerant of shade than oak species, and are therefore better able to survive in the low-light conditions beneath the forest canopy. Disturbances that allow more light to the understory can promote oak seedling establishment and recruitment into the canopy.

The maintenance of quality oak forests in the park will require efforts to increase the regeneration of oak species. A combination of deer browse control measures and silvicultural treatments such as shelterwoods will promote the recruitment of oak in the park's existing oak-dominated forests. Possible deer browse control measures may include reducing the deer population or establishing deer exclosure fences around high quality oak stands to promote oak seedling survival. Then, silvicultural prescriptions that favor oak regeneration could be applied to the oak and tuliptree forests to encourage oak seedling establishment and recruitment into the canopy.

Vegetation Map Production

The original formation-level vegetation map identified eight vegetation types and three Anderson level II categories (modified): built-up land, transportation corridor, and right-of-way. The final

vegetation association map for Fort Necessity National Battlefield includes eight vegetation associations and two Anderson level II categories (modified): built-up land and transportation corridor. In the association-level map, the right-of-way was mapped as Successional Old Field because that association accurately describes the right-of-way vegetation.

Since the NVCS is hierarchical, there are typically several vegetation associations assigned to one formation-level vegetation type. The hardwood forest types in Fort Necessity National Battlefield followed this model. Polygons labeled with the formation-level vegetation type Lowland or submontane cold-deciduous forest were then assigned one of the five hardwood forest types, Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, Sugar Maple – Basswood Forest, Tuliptree Forest, or Red Maple – Black Cherry Successional Forest, after the vegetation analysis. However, due to the varied historical land use and ongoing management prescriptions, there were instances in the park where several formation-level vegetation types were assigned to a single association. For example, Mixed needle-leaved evergreen - cold-deciduous forest, Conical-crowned temperate evergreen forest, and Conical-crowned temperate evergreen woodland formation-level types were all labeled as Conifer Plantation in the final map. Also, polygons labeled Medium tall sod temperate or subpolar grassland, Temperate cold-deciduous shrubland, and Cold-deciduous woodland in the formation-level map were assigned to the vegetation type Successional Old Field in the final association map. Although this seems contrary to the hierarchical nature of the NVCS, it reflects the great variability in vegetation structure caused by past silviculture, natural resource management, and natural succession. Splitting the Conifer Plantation and Successional Old Field types into additional associations based on their formation-level vegetation types would create types that are too difficult to identify and effectively manage due to the wide range of natural variability. One formation-level vegetation type, Seasonally flooded herbaceous vegetation, was assigned to only one association, Wet Meadow.

The final vegetation map is based on the aerial photography that was flown in April 2003. Since that time, the vegetation in the park continues to change. The creation of a new visitors' center in the park's Main Unit has significantly altered the vegetation at the new center's location. Recent honeysuckle removal projects have decreased the shrub cover in some of the fields. Natural succession in the Successional Old Field, Red Maple – Black Cherry Successional Forest, and Conifer Plantation types will continue to alter the mapped vegetation. Despite these changes, the vegetation map produced by this project provides crucial baseline data for the park resource managers.

Recommendations for Future Projects

Further study of the vegetation associations at Fort Necessity National Battlefield should concentrate on the southwestern corner of the park's Main Unit. This section of the map reported a high rate of error in distinguishing between the three hardwood forest types, Northern Red Oak – Mixed Hardwood Forest, White Oak – Mixed Hardwood Forest, and Tuliptree Forest. An additional intensive accuracy assessment sampling effort focused on this section would improve the thematic accuracy of the map. Accuracy assessment sampling points could be laid out in a grid with points 100 m (328 ft) apart. This would allow for the more accurate delineation of the polygon boundaries. This additional accuracy assessment would likely confirm that the three hardwood forest types exist in the park and commonly intergrade, creating

frequently occurring ecotones. The additional mapping precision gained from this analysis is also unlikely to affect the management of this section of the park. Therefore, the costs (approximately $5,000–$10,000) of such an analysis are not justified by the benefits.

Continued inventory, monitoring, and management of invasive species such as Morrow's honeysuckle, multiflora rose, Japanese barberry, Japanese stilt grass, purple crownvetch, teasel, bull thistle, and Canadian thistle should be a priority for the park's resource managers. A study being conducted by the Western Pennsylvania Conservancy on the status of invasive species in Fort Necessity National Battlefield will provide crucial information towards this end and is scheduled for completion around October 2005.

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Appendix A. Aerial photograph interpretation keys to formation-level vegetation types and vegetation associations at Fort Necessity National Battlefield.

AERIAL PHOTOGRAPH INTERPRETATION KEY TO FORMATION-LEVEL VEGETATION TYPES AT FORT NECESSITY NATIONAL BATTLEFIELD for April 2003 Color Infrared Aerial Photography

1. Individual tree crowns visible as gray, black, or pink signatures of varying architecture. Trees cover greater than 30% of area.

    2. Signatures of trees are pink and conical, indicating evergreen trees.

        3. Evergreen tree crowns cover greater than 60% of the area, creating a near continuous pink canopy of conical crowns.

        Conical-crowned temperate evergreen forest

        3. Evergreen tree crowns cover 60% or less of the area, interspersed with light to dark gray deciduous tree crowns, or occurring within a matrix of white to light gray herbaceous vegetation.

            4. Pink conical evergreen tree crowns are interspersed with light to dark gray deciduous tree crowns, creating a near continuous canopy.

            Mixed needle-leaved evergreen - cold-deciduous forest

            4. Evergreen tree crowns are scattered or clumped within a matrix of white to light gray herbaceous vegetation.

            Conical-crowned temperate evergreen woodland

    2. Signatures of trees are light to dark gray or black, indicating cold-deciduous trees.

        5. Tree crowns cover greater than 60% of the area, creating a near continuous canopy.

        Lowland or submontane cold-deciduous forest

        5. Tree crowns cover 60% or less of the area, such that individual trees or clumps of trees are visible in a matrix of white to light gray herbaceous vegetation. Gray shrubs may also be present.

        Cold-deciduous woodland

1. Individual tree crowns cover less than 30% of the area.

    6. Signature is primarily white to medium gray, ranging from uniform to mottled. Buildings, structures, parking lots, and roads are absent.

7. Shrubs cover greater than 30% of the area, appearing as round gray circles, scattered or in clumps within a matrix of white to light gray herbaceous vegetation. Areas of dense shrub cover will have a bumpy gray signature.

Temperate cold-deciduous shrubland

7. Shrubs cover 30% or less of the area. Signature is almost entirely white to light gray herbaceous vegetation, ranging from uniform to mottled.

8. White to light gray herbaceous vegetation signature occurs as a thin linear feature surrounded by a different vegetation signature, often forest.

Right-of-way

8. White to light gray herbaceous vegetation signature occurs as a polygon, not as a thin linear feature. May contain scattered shrubs as round gray circles, or scattered individual tree crowns.

9. Signature tends to be uniformly white with light to dark gray circular patches indicating shrubs.

Medium tall sod temperate or subpolar grassland

9. Signature is white with speckled or dappled gray sections that indicate saturated soil and hummocky herbaceous vegetation. Dark gray linear drainage features may be present.

Seasonally flooded herbaceous vegetation

6. Buildings, structures, parking lots and roads present, often surrounded by frequently mowed turf grass that has a light to bright pink signature.

10. Buildings, structures, and parking lots, often surrounded by frequently mowed turf grass that has a light, bright pink signature.

Built-up land

10. Roads and highways have a linear uniform light gray to blue-gray signature often with visible lane lines and automobiles.

Transportation corridor

AERIAL PHOTOGRAPH INTERPRETATION KEY TO VEGETATION ASSOCIATIONS AT FORT NECESSITY NATIONAL BATTLEFIELD for April 2003 Color Infrared Aerial Photography

1. Individual tree crowns visible as gray, black, or pink signatures of varying architecture. Trees cover greater than 30% of area.

    2. Tree signatures are pink and conical, indicating evergreen trees. Tree crowns can cover the majority of the area, creating a near continuous pink canopy of conical crowns. Tree crowns can also be interspersed with light to dark gray deciduous tree crowns or be scattered or clumped within a matrix of white to light gray herbaceous vegetation. Buildings, structures or parking lots are absent (if present, see couplet 6 below).
    Conifer Plantation

    2. Tree signatures are light to dark gray or black, indicating cold-deciduous trees. (The associations in couplets 4 and 5 below may be indistinguishable from each other on the aerial photography. Field verification may be necessary for positive identification.)

        3. Trees have somewhat consistent mature height and regular spacing. Groundstory varies from bright white to mottled brown and pink and is consistently visible through the mature tree crowns.

            4. Tree crowns are light gray to light brown, symmetrical, fine-branched, and tall. Often emergent crowns are visible above a varied subcanopy. Groundstory varies from uniform bright white to mottled brown and pink with an uneven texture in areas with high cover of low shrubs, invasive species or vines.
            Tuliptree Forest

            4. Tree crowns are dark gray with open asymmetrical canopies and coarse craggy branches. Groundstory varies from bright white to mottled brown and pink.

                5. Tree crowns are dark gray with open asymmetrical canopies and coarse craggy branches. Groundstory is consistently bright white with occasional scattered dark patches indicative of seeps. Typically associated with mid to upper slopes.
                White Oak – Mixed Hardwood Forest

                5. Tree crowns are dark gray with open asymmetrical canopies and coarse craggy branches. Groundstory varies from bright white to mottled brown and pink. Typically associated with mid to lower slopes. (Note: The Sugar Maple – Basswood Forest is indistinguishable from Northern Red Oak – Mixed

Hardwood Forest on the aerial photography, however, the former is extremely geographically limited in the Jumonville Glen Unit of Fort Necessity National Battlefield.)

Northern Red Oak – Mixed Hardwood Forest

3. Forest signature is variable, and can include dense bumpy gray signature of young trees, uneven canopy heights, small interspersed patches of white to light gray open herbaceous vegetation. Often has dense bumpy gray or brown signature of a thick tall shrub layer in parts. Groundstory is mottled with brown and pink and has uneven texture in areas with high cover of low shrubs, invasive species or vines.

Red Maple – Black Cherry Successional Forest

1. Individual tree crowns cover less than 30% of the area.

6. Signature is predominantly white to light gray herbaceous vegetation, ranging from uniform to mottled. Shrubs, appearing as round gray circles, may be present or absent, scattered or in clumps within the white to light gray matrix of herbaceous vegetation. Areas of dense shrub cover will have a bumpy gray signature. Buildings, structures, parking lots, and roads are absent.

7. White to light gray herbaceous vegetation signature contains gray to black speckled or textured areas that indicate saturated or inundated soil. Gray to black linear drainage features are prominent or common. Vegetation is associated with swales, lowlands and streams. (This association may be indistinguishable from Successional Old Field on aerial photography.)

Wet Meadow

7. Signature has fairly uniform texture although color can be mottled white, light gray and/or light pink. Gray to black speckled or textured areas that indicate saturated or inundated soil are absent. Individual tree crowns and shrubs may be present or absent, scattered or in clumps. Areas of dense shrub cover will have a bumpy gray signature. (This association type may be indistinguishable from Wet Meadow on aerial photography.)

Successional Old Field

6. Buildings, structures, parking lots and roads present, often surrounded by frequently mowed turf grass that has a light to bright pink signature or scattered tree crowns.

8. Buildings, structures, and parking lots, often surrounded by frequently mowed turf grass that has a light, bright pink signature.

Built-up land

8. Roads and highways have a linear uniform light gray to blue-gray signature often with visible lane lines and automobiles.

Transportation corridor

Appendix B. Vegetation plot sampling form.

NPS 6 Parks Vegetation Mapping Project

A. General Information

Plot Number:_____ Park Name:_____

Survey date: _____ Surveyors:_____

Easting: _ _ _ _ _ _ E Northing:_ _ _ _ _ _ _ N EPE/APE:_____ DOP:_____ Map datum:_____ Zone:_____

B. Environmental Description

Representative sketch of stand and landscape position

Picture No.:_____

Slope: _____

Aspect: _____

Elevation: _____

Stoniness:

___ Stone free <0.1%
___ Moderately stony 0.1–1%
___ Stony 3–15%
___ Very stony 15–50%
___ Exceedingly stony 50–90%
___ Stone piles >90%

Topographic position:

___ Interfluve (ridgetop)
___ High slope
___ High level
___ Midslope
___ Backslope
___ Step in slope
___ Other: _____
___ Low slope
___ Toe slope
___ Low level
___ Channel wall
___ Channel bed
___ Basin Floor

Hydrologic regime:

___ Permanently flooded
___ Semi-permanently flooded
___ Seasonally flooded
___ Intermittently flooded
___ Temporarily flooded
___ Artificially flooded
___ Saturated (wet, but never flooded)

Average soil texture:

___ sand
___ sandy loam
___ loam
___ silt loam
___ other: _____
___ clay loam
___ clay
___ peat
___ muck

Soil drainage:

___ Rapidly drained
___ Well drained
___ Moderately well drained
___ Somewhat poorly drained
___ Poorly Drained
___ Very poorly drained

Soil profile description: note depth, texture, and color of each horizon. Note significant changes such as depth to mottling, depth to water table, root penetration depth

Horizon	Depth	Texture	Color	pH	Comments

Unvegetated surface:

_____ % Bedrock
_____ % Litter, duff
_____ % Large rocks (> 10 cm)
_____ % Wood (> 1 cm)
_____ % Small rocks (0.2–10 cm)
_____ % Water
_____ % Sand (0.1–2 mm)
_____ % Bare soil
_____ % Other: _____

Plot representativeness: Note homogeneity of vegetation in plot versus rest of community

Environmental Comments: Note surrounding vegetation, landscape context, herbivory, stand health, recent/historic anthropogenic evidence, etc.

C. Vegetation

Cowardin System: _____ Terrestrial _____ Palustrine _____ Estuarine Plot number:_____ Plot dimensions: _____

Leaf Type	Leaf Phenology	Physiognomic Type			height	% cover
___ Broad-leaf	___ Deciduous	___ Forest	___ Woodland	T1 Emergent tree		
___ Semi-broad-leaf	___ Semi-deciduous	___ Sparse Woodland	___ Scrub Thicket	T2 Tree canopy		
___ Semi-needle-leaf	___ Semi-evergreen	___ Shrubland	___ Sparse Woodland	T3 Tree sub-canopy		
___ Needle-leaf	___ Evergreen	___ Dwarf Shrubland	___ Dwarf Scrub Thicket	S1 Tall shrub		
___ Broad-leaf herbaceous	___ Perennial	___ Sparse Dwarf Shrubland	___ Herbaceous	S2 Short shrub		
___ Graminoid	___ Annual	___ Non-Vascular	___ Sparsely Vegetated	H Herbaceous		
___ Pteridophyte				N Non-vascular		
				E Epiphyte		
				V Vine / liana		

R = 1 or few (+) = occasional 1 = <5% 2- = 5–12% 2+ = 13–25% 3 = 26–50% 4 = 51–75% 5 = 76+%

Species / percent cover: starting with uppermost 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.

Appendix C. Plants observed in Fort Necessity National Battlefield during vegetation plot and thematic accuracy assessment sampling.

Plants Observed in Fort Necessity National Battlefield
During Vegetation Plot and Thematic Accuracy Assessment Sampling

Nomenclature follows *The PLANTS Database, Version 3.5,* developed by the Natural Resource Conservation Service in cooperation with the Biota of North America Program (United States Department of Agriculture, National Resources Conservation Service 2004). For this report, some common names listed in *The PLANTS Database* were changed to reflect the common names typically used by ecologists and resource managers in this region. In addtion, the scientific name *Actaea racemosa* is used in this report instead of *Cimicifuga racemosa* in order to maintain consistency with the National Vegetation Classificatin System. The common and scientific names of plants observed during the vegetation plot and thematic accuracy assessment sampling are listed below.

Family	Scientific Name	Common Name
Aceraceae	*Acer rubrum*	red maple
	Acer saccharum	sugar maple
Alismataceae	*Sagittaria latifolia*	broadleaf arrowhead
Anacardiaceae	*Toxicodendron radicans*	eastern poison ivy
Apiaceae	*Cicuta maculata*	spotted water hemlock
	Daucus carota	Queen Anne's lace
	Osmorhiza claytonii	Clayton's sweetroot
	Sanicula canadensis	Canadian blacksnakeroot
Apocynaceae	*Apocynum androsaemifolium*	spreading dogbane
	Apocynum cannabinum	Indian hemp
	Vinca minor	common periwinkle
Aquifoliaceae	*Ilex verticillata*	common winterberry
Araceae	*Arisaema triphyllum*	Jack in the pulpit
	Symplocarpus foetidus	skunk cabbage
Araliaceae	*Aralia nudicaulis*	wild sarsaparilla
	Panax quinquefolius	American ginseng
Asclepiadaceae	*Asclepias incarnata*	swamp milkweed
	Asclepias syriaca	common milkweed
	Asclepias tuberosa	butterfly milkweed
Aspleniaceae	*Asplenium platyneuron*	ebony spleenwort
Asteraceae	*Achillea millefolium*	common yarrow
	Ageratina altissima var. *altissima*	white snakeroot
	Ambrosia ambrosioides	ambrosia leaf burr ragweed
	Antennaria plantaginifolia	woman's tobacco
	Arctium minus	lesser burrdock
	Bidens connata	purplestem beggarticks
	Bidens sandvicensis ssp. *sandvicensis*	shrubland beggarticks
	Cirsium arvense	Canada thistle
	Cirsium vulgare	bull thistle
	Doellingeria umbellata var. *umbellata*	parasol whitetop
	Erigeron strigosus	prairie fleabane
	Eupatorium fistulosum	trumpetweed
	Eupatorium maculatum	spotted joepyeweed

Family	Scientific Name	Common Name
Asteraceae (cont.)	*Eurybia divaricata*	white wood aster
	Eurybia macrophylla	bigleaf aster
	Euthamia graminifolia	flat-top goldenrod
	Helianthus strumosus	paleleaf woodland sunflower
	Hieracium aurantiacum	orange hawkweed
	Lactuca canadensis	Canada lettuce
	Leucanthemum vulgare	ox-eye daisy
	Packera aurea	golden ragwort
	Prenanthes alba	white rattlesnakeroot
	Rudbeckia hirta	blackeyed Susan
	Solidago caesia	wreath goldenrod
	Solidago canadensis	Canada goldenrod
	Solidago canadensis var. *scabra*	Canada goldenrod
	Solidago gigantea	giant goldenrod
	Solidago juncea	early goldenrod
	Solidago nemoralis	gray goldenrod
	Solidago rugosa	wrinkleleaf goldenrod
	Solidago rugosa ssp. *aspera*	wrinkleleaf goldenrod
	Solidago rugosa ssp. *rugosa*	wrinkleleaf goldenrod
	Symphyotrichum lateriflorum var. *lateriflorum*	calico aster
	Symphyotrichum pilosum var. *pilosum*	hairy white oldfield aster
	Symphyotrichum prenanthoides	crookedstem aster
	Taraxacum officinale	common dandelion
	Vernonia noveboracensis	New York ironweed
Balsaminaceae	*Impatiens capensis*	jewelweed
Berberidaceae	*Berberis thunbergii*	Japanese barberry
	Berberis vulgaris	common barberry
	Caulophyllum thalictroides	blue cohosh
	Podophyllum peltatum	mayapple
Betulaceae	*Alnus incana* ssp. *rugosa*	speckled alder
	Betula alleghaniensis	yellow birch
	Betula lenta	sweet birch
	Betula nigra	river birch
	Carpinus caroliniana	American hornbeam
	Corylus americana	American hazelnut
	Ostrya virginiana	hophornbeam
Campanulaceae	*Lobelia inflata*	Indian-tobacco
	Lobelia spicata	palespike lobelia
	Lobelia spicata var. *spicata*	palespike lobelia
Caprifoliaceae	*Lonicera morrowii*	Morrow's honeysuckle
	Lonicera tatarica	Tatarian honeysuckle
	Sambucus nigra ssp. *canadensis*	common elderberry
	Viburnum acerifolium	mapleleaf viburnum
	Viburnum dentatum var. *lucidum*	southern arrowwood
	Viburnum prunifolium	blackhaw
Caryophyllaceae	*Cerastium fontanum*	common mouse-ear chickweed

Family	*Scientific Name*	Common Name
Caryophyllaceae (cont.)	*Dianthus armeria*	Deptford pink
	Stellaria graminea	grasslike starwort
	Stellaria pubera	star chickweed
Celastraceae	*Euonymus alata*	winged burning bush
Clusiaceae	*Hypericum densiflorum*	bushy St. John’s wort
	Hypericum perforatum	common St. Johnswort
	Hypericum prolificum	shrubby St. John's wort
	Hypericum punctatum	spotted St. John's wort
Convolvulaceae	*Calystegia spithamaea*	low false bindweed
Cornaceae	*Cornus alternifolia*	alternateleaf dogwood
	Cornus florida	flowering dogwood
	Cornus foemina	stiff dogwood
	Cornus sericea	redosier dogwood
Crassulaceae	*Sedum ternatum*	woodland stonecrop
Cyperaceae	*Carex albursina*	white bear sedge
	Carex blanda	eastern woodland sedge
	Carex debilis	white edge sedge
	Carex digitalis	slender woodland sedge
	Carex glaucodea	blue sedge
	Carex gracillima	graceful sedge
	Carex intumescens	greater bladder sedge
	Carex laxiculmis	spreading sedge
	Carex laxiculmis var. *copulata*	spreading sedge
	Carex laxiculmis var. *laxiculmis*	spreading sedge
	Carex laxiflora	broad looseflower sedge
	Carex lurida	shallow sedge
	Carex molesta	troublesome sedge
	Carex normalis	greater straw sedge
	Carex pensylvanica	Pennsylvania sedge
	Carex radiata	eastern star sedge
	Carex rosea	rosy sedge
	Carex scoparia	broom sedge
	Carex stricta	tussock sedge
	Carex swanii	Swan's sedge
	Carex torta	twisted sedge
	Carex vulpinoidea	fox sedge
	Eleocharis sp.	spikerush
	Scirpus atrovirens	green bulrush
	Scirpus cyperinus	woolgrass
	Scirpus georgianus	Georgia bulrush
	Scirpus polyphyllus	leafy bulrush
Dennstaedtiaceae	*Dennstaedtia punctilobula*	eastern hayscented fern
	Pteridium aquilinum	western brackenfern
Dioscoreaceae	*Dioscorea quaternata*	fourleaf yam
	Deparia acrostichoides	silver false spleenwort
	Dryopteris carthusiana	spinulose woodfern

Family	Scientific Name	Common Name
Dioscoreaceae (cont.)	*Dryopteris cristata*	crested woodfern
	Dryopteris intermedia	intermediate woodfern
	Matteuccia struthiopteris	ostrich fern
	Onoclea sensibilis	sensitive fern
	Polystichum acrostichoides	Christmas fern
Elaeagnaceae	*Elaeagnus umbellata*	autumn olive
Ericaceae	*Gaultheria procumbens*	eastern teaberry
	Gaylussacia baccata	black huckleberry
	Rhododendron periclymenoides	pink azalea
	Vaccinium angustifolium	lowbush blueberry
	Vaccinium pallidum	Blue Ridge blueberry
	Vaccinium stamineum	deerberry
Fabaceae	*Amphicarpaea bracteata*	American hogpeanut
	Coronilla varia	purple crownvetch
	Desmodium canescens	hoary ticktrefoil
	Melilotus officinalis	yellow sweetclover
	Robinia pseudoacacia	black locust
	Trifolium pratense	red clover
Fagaceae	*Castanea dentata*	American chestnut
	Fagus grandifolia	American beech
	Quercus alba	white oak
	Quercus bicolor	swamp white oak
	Quercus coccinea	scarlet oak
	Quercus prinus	chestnut oak
	Quercus rubra	northern red oak
	Quercus velutina	black oak
Gentianaceae	*Gentiana clausa*	bottle gentian
Geraniaceae	*Geranium maculatum*	spotted geranium
Grossulariaceae	*Ribes rotundifolium*	Appalachian gooseberry
Hamamelidaceae	*Hamamelis virginiana*	American witchhazel
Iridaceae	*Iris virginica*	Virginia iris
	Sisyrinchium angustifolium	narrowleaf blue-eyed grass
Juglandaceae	*Carya cordiformis*	bitternut hickory
	Carya glabra	pignut hickory
	Carya ovata	shagbark hickory
	Juglans nigra	black walnut
Juncaceae	*Juncus canadensis*	Canadian rush
	Juncus effusus	common rush
	Juncus tenuis	poverty rush
	Luzula acuminata	hairy woodrush
	Luzula echinata	hedgehog woodrush
Lamiaceae	*Clinopodium vulgare*	wild basil
	Glechoma hederacea	ground ivy
	Lycopus uniflorus	northern bugleweed
	Lycopus virginicus	Virginia water horehound
	Mentha sp.	mint

Family	Scientific Name	Common Name
Lamiaceae (cont.)	*Prunella vulgaris*	common selfheal
	Pycnanthemum tenuifolium	narrowleaf mountainmint
	Scutellaria lateriflora	blue skullcap
Lauraceae	*Lindera benzoin*	northern spicebush
	Sassafras albidum	sassafras
Liliaceae	*Allium vineale*	wild garlic
	Chamaelirium luteum	fairywand
	Clintonia borealis	bluebead
	Clintonia umbellulata	white clintonia
	Disporum lanuginosum	yellow fairybells
	Maianthemum canadense	Canada mayflower
	Maianthemum racemosum ssp. *racemosum*	feathery false lily of the valley
	Medeola virginiana	Indian cucumber
	Polygonatum pubescens	hairy Solomon's seal
	Streptopus lanceolatus var. *roseus*	twistedstalk
	Uvularia grandiflora	largeflower bellwort
	Uvularia perfoliata	perfoliate bellwort
	Uvularia sessilifolia	sessileleaf bellwort
Lycopodiaceae	*Lycopodium digitatum*	fan clubmoss
	Lycopodium obscurum	rare clubmoss
Magnoliaceae	*Liriodendron tulipifera*	tuliptree
	Magnolia acuminata	cucumber-tree
Monotropaceae	*Monotropa uniflora*	Indianpipe
Nyssaceae	*Nyssa sylvatica*	blackgum
Oleaceae	*Fraxinus americana*	white ash
	Fraxinus pennsylvanica	green ash
	Ligustrum vulgare	European privet
Onagraceae	*Circaea alpina*	small enchanter's nightshade
	Circaea lutetiana	broadleaf enchanter's nightshade
	Epilobium coloratum	purpleleaf willowherb
	Oenothera perennis	little evening-primrose
Ophioglossaceae	*Botrychium dissectum*	cutleaf grapefern
	Botrychium matricariifolium	matricary grapefern
	Botrychium virginianum	rattlesnake fern
Orchidaceae	*Cypripedium acaule*	moccasin flower
	Goodyera pubescens	downy rattlesnake plantain
	Platanthera clavellata	small green wood orchid
	Platanthera orbiculata	lesser roundleaved orchid
	Spiranthes cernua	nodding ladies'-tresses
Orobanchaceae	*Conopholis americana*	American squawroot
Osmundaceae	*Osmunda cinnamomea*	cinnamon fern
	Osmunda claytoniana	interrupted fern
Oxalidaceae	*Oxalis stricta*	common yellow oxalis
Phytolaccaceae	*Phytolacca americana*	American pokeweed
Pinaceae	*Larix kaempferi*	Japanese larch

Family	Scientific Name	Common Name
Pinaceae (cont.)	*Picea abies*	Norway spruce
	Pinus resinosa	red pine
	Pinus strobus	eastern white pine
	Pinus sylvestris	Scotch pine
	Tsuga canadensis	eastern hemlock
Plantaginaceae	*Plantago lanceolata*	narrowleaf plantain
	Plantago major	common plantain
Poaceae	*Agrostis capillaris*	colonial bentgrass
	Agrostis scabra	rough bentgrass
	Agrostis stolonifera	creeping bentgrass
	Andropogon virginicus	broomsedge bluestem
	Anthoxanthum odoratum	sweet vernalgrass
	Brachyelytrum erectum	bearded shorthusk
	Cinna arundinacea	sweet woodreed
	Cynodon dactylon	Bermuda grass
	Dactylis glomerata	orchardgrass
	Danthonia compressa	flattened oatgrass
	Dichanthelium acuminatum var. *acuminatum*	tapered rosette grass
	Dichanthelium clandestinum	deertongue
	Dichanthelium dichotomum var. *dichotomum*	cypress panicgrass
	Glyceria melicaria	melic mannagrass
	Glyceria striata	fowl mannagrass
	Holcus lanatus	common velvetgrass
	Leersia oryzoides	rice cutgrass
	Leersia virginica	whitegrass
	Lolium perenne	perennial ryegrass
	Lolium pratense	meadow ryegrass
	Microstegium vimineum	Japanese stilt grass
	Muhlenbergia frondosa	wirestem muhly
	Panicum sp.	panicgrass
	Phalaris arundinacea	reed canarygrass
	Phleum pratense	timothy
	Poa alsodes	grove bluegrass
	Poa pratensis	Kentucky bluegrass
Polygalaceae	*Polygala sanguinea*	purple milkwort
Polygonaceae	*Polygonum persicaria*	spotted ladysthumb
	Polygonum punctatum	dotted smartweed
	Polygonum sagittatum	arrowleaf tearthumb
	Polygonum virginianum	jumpseed
	Rumex acetosella	common sheep sorrel
	Rumex crispus	curly dock
	Rumex obtusifolius	bitter dock
Primulaceae	*Lysimachia lanceolata*	lanceleaf loosestrife
	Lysimachia quadrifolia	whorled yellow loosestrife
	Trientalis borealis	starflower
Pteridaceae	*Adiantum pedatum*	northern maidenhair

Family	Scientific Name	Common Name
Pyrolaceae	*Chimaphila maculata*	striped prince's pine
	Orthilia secunda	sidebells wintergreen
	Pyrola sp.	wintergreen
Ranunculaceae	*Actaea racemosa*	black bugbane
	Clematis terniflora	sweet autumn virginsbower
	Clematis virginiana	devil's darning needles
	Ranunculus abortivus	littleleaf buttercup
	Ranunculus hispidus	bristly buttercup
	Ranunculus recurvatus	blisterwort
	Thalictrum dioicum	early meadow-rue
	Thalictrum pubescens	king of the meadow
	Thalictrum thalictroides	rue anemone
Rosaceae	*Agrimonia gryposepala*	tall hairy agrimony
	Amelanchier arborea	common serviceberry
	Crataegus flabellata	fanleaf hawthorn
	Fragaria virginiana	Virginia strawberry
	Geum canadense	white avens
	Malus coronaria	sweet crabapple
	Malus pumila	paradise apple
	Physocarpus opulifolius	common ninebark
	Potentilla simplex	common cinquefoil
	Prunus serotina	black cherry
	Prunus virginiana	chokecherry
	Rosa multiflora	multiflora rose
	Rubus allegheniensis	Allegheny blackberry
	Rubus flagellaris	northern dewberry
	Rubus hispidus	bristly dewberry
	Rubus idaeus	American red raspberry
	Rubus occidentalis	black raspberry
	Spiraea alba	white meadowsweet
Rubiaceae	*Galium aparine*	cleavers
	Galium asprellum	rough bedstraw
	Galium circaezans	licorice bedstraw
	Galium lanceolatum	lanceleaf wild licorice
	Galium mollugo	false baby's breath
	Galium tinctorium	stiff marsh bedstraw
	Galium triflorum	fragrant bedstraw
	Houstonia purpurea	Venus' pride
	Mitchella repens	partridgeberry
Salicaceae	*Populus grandidentata*	bigtooth aspen
Saxifragaceae	*Tiarella cordifolia*	heartleaf foamflower
Scrophulariaceae	*Mimulus ringens*	Allegheny monkeyflower
	Veronica americana	American speedwell
	Veronica officinalis	common gypsyweed
	Veronica persica	birdeye speedwell
	Veronicastrum virginicum	Culver's root

Family	Scientific Name	Common Name
Simaroubaceae	*Ailanthus altissima*	tree of heaven
Smilacaceae	*Smilax glauca*	cat greenbrier
	Smilax herbacea	smooth carrionflower
	Smilax rotundifolia	roundleaf greenbrier
	Smilax tamnoides	bristly greenbrier
Solanaceae	*Physalis heterophylla*	clammy groundcherry
	Solanum carolinense	Carolina horsenettle
	Solanum dulcamara	climbing nightshade
Sphagnaceae	*Sphagnum* sp.	sphagnum
Taxaceae	*Taxus canadensis*	Canada yew
Thelypteridaceae	*Thelypteris noveboracensis*	New York fern
Tiliaceae	*Tilia americana*	basswood
Ulmaceae	*Ulmus americana*	American elm
	Ulmus rubra	slippery elm
Urticaceae	*Laportea canadensis*	Canadian woodnettle
	Pilea pumila	Canadian clearweed
Verbenaceae	*Verbena hastata*	swamp verbena
Violaceae	*Viola canadensis*	Canadian white violet
	Viola cucullata	marsh blue violet
	Viola hastata	halberdleaf yellow violet
	Viola odorata	sweet violet
	Viola palmata	early blue violet
	Viola pubescens	downy yellow violet
	Viola rotundifolia	roundleaf yellow violet
	Viola sagittata	arrowleaf violet
	Viola sororia	common blue violet
	Viola striata	striped cream violet
Vitaceae	*Parthenocissus quinquefolia*	Virginia creeper
	Vitis aestivalis	summer grape

Appendix D. Dichotomous field key to the vegetation associations of Fort Necessity National Battlefield.

DICHOTOMOUS FIELD KEY TO THE VEGETATION ASSOCIATIONS OF FORT NECESSITY NATIONAL BATTLEFIELD

1. HERBACEOUS AND SHRUB VEGETATION: TREE COVER LESS THAN 30%.

    2. Herbaceous layer dominated by hydrophytic species such as tussock sedge (*Carex stricta*), common rush (*Juncus effusus*), green bulrush (*Scirpus atrovirens*), rice cutgrass (*Leersia oryzoides*), spikerush (*Eleocharis* spp.), sensitive fern (*Onoclea sensibilis*), and sweet woodreed (*Cinna arundinacea*). Soil is saturated for at least part of the growing season.

    Wet Meadow

    2. Herbaceous layer dominated by a mix of grasses and herbs, predominantly goldenrods (*Solidago* spp.), creeping bentgrass (*Agrostis stolonifera*), flattened oat grass (*Danthonia compressa*), bluegrasses (*Poa* spp.), panic grasses (*Panicum* spp.), common yarrow (*Achillea millefolium*), sweet vernalgrass (*Anthoxanthum odoratum*), common velvetgrass (*Holcus lanatus*), Queen Anne's lace (*Daucus carota*), timothy (*Phleum pratense*), narrowleaf mountainmint (*Pycnanthemum tenuifolia*), and orchardgrass (*Dactylis glomerata*). Tall or short shrubs may cover up to 80% of the area; common species include: Morrow's honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), apples (*Malus* spp.) and hawthorns (*Crataegus* spp.).

    Successional Old Field

1. FOREST AND WOODLAND, TREE COVER GREATER THAN 30%.

    3. Tree cover between 30 – 60%.

        4. Scattered tree canopy contains black cherry (*Prunus serotina*), apples (*Malus* spp.) and hawthorns (*Crataegus* spp.). Shrub and herbaceous layers are as described above in couplet 2 above.

        Successional Old Field

        4. Conifer species such as red pine (*Pinus resinosa*), white pine (*Pinus strobus*), Norway spruce (*Picea abies*) and/or Japanese larch (*Larix kaempferi*) comprise greater than 50% of woodland canopy. Evidence of silvicultural treatments may be present. Adventitious hardwoods such as black cherry (*Prunus serotina*), red maple (*Acer rubrum*), and white ash (*Fraxinus americana*) may also be present in the canopy.

        Conifer Plantation

    3. Tree cover greater than 60%.

        5. Conifer species, such as red pine (*Pinus resinosa*), white pine (*Pinus strobus*), Norway spruce (*Picea abies*) and/or Japanese larch (*Larix kaempferi*) comprise greater than 50% of the forest canopy. Evidence of silvicultural treatments may be

present. Adventitious hardwoods such as black cherry (*Prunus serotina*), red maple (*Acer rubrum*), and white ash (*Fraxinus americana*) may also be present in the canopy.

Conifer Plantation

5. Conifer species less than 50% of the canopy.

    6. Oak (*Quercus* spp.) absent or sparse; oak species comprising less than 15% tree canopy.

        7. Tuliptree (*Liriodendron tulipifera*) is common to dominant (15–80% cover), with associates of red maple (*Acer rubrum*) or black cherry (*Prunus serotina*). Red maple may be abundant in the canopy and subcanopy, under an emergent layer of tuliptrees. Invasive shrubs such as Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*) and Morrow's honeysuckle (*Lonicera morrowii*) are often common.

Tuliptree Forest

        7. Tuliptree (*Liriodendron tulipifera*) absent or sparse, comprising less than 15% of the canopy. Canopy is dominated by black cherry (*Prunus serotina*) and/or red maple (*Acer rubrum*). In young weedy stands, black locust (*Robinia pseudoacacia*), Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*) and Morrow's honeysuckle (*Lonicera morrowii*) are common. In older established stands, northern spicebush (*Lindera benzoin*), American hornbeam (*Carpinus caroliniana*), and southern arrowwood (*Viburnum dentatum* var. *lucidum*) are common shrubs, with occasional sugar maple (*Acer saccharum*) and oaks (*Quercus* spp.) in the canopy.

Red Maple – Black Cherry Successional Forest

    6. Oak (*Quercus* spp.) comprising greater than 15% tree canopy.

        8. Oak (*Quercus* spp.) dominates the tree canopy, comprising greater than 50% tree cover.

            9. Northern red oak (*Quercus rubra*) is dominant in the emergent and canopy layers, red maple (*Acer rubrum*) is dominant in the canopy and subcanopy layers, and cucumber-tree (*Magnolia acuminata*) is dominant in the subcanopy. Other common canopy species include pignut hickory (*Carya glabra*), chestnut oak (*Quercus prinus*) and black oak (*Quercus velutina*). American chestnut (*Castanea dentata*) may be present in the shrub layers. This forest often found on mid to lower slopes.

Northern Red Oak – Mixed Hardwood Forest

            9. White oak (*Quercus alba*), northern red oak (*Quercus rubra*) and red maple (*Acer rubrum*) are dominant in the canopy. This forest type is typically found on upper slopes, however, it often contains small seeps

and drainages. Ericaceous species such as blueberries (*Vaccinium* spp.) and New York fern (*Thelypteris noveboracensis*) are common on higher slopes. In seeps and drainages, northern spicebush (*Lindera benzoin*), bristly dewberry (*Rubus hispidus*), cinnamon fern (*Osmunda cinnamomea*), and sensitive fern (*Onoclea sensibilis*) are common.

White Oak – Mixed Hardwood Forest

8. Oak (*Quercus* spp.) comprises between 15 – 50% of the canopy, with other hardwood species dominant in the canopy.

    10. The dominant tree is tuliptree (*Liriodendron tulipifera*), although it can share dominance with red maple (*Acer rubrum*), black cherry (*Prunus serotina*) and northern red oak (*Quercus rubra*).

    Tuliptree Forest

    10. Basswood (*Tilia americana*) and sugar maple (*Acer saccharum*) dominate the canopy, with northern red oak (*Quercus rubra*), red maple (*Acer rubrum*) and cucumber-tree (*Magnolia acuminata*) also present. Northern spicebush (*Lindera benzoin*) dominates that dense tall shrub layer. This forest is found in flat low-lying areas that contain calcareous bedrock.

    Sugar Maple – Basswood Forest

Appendix E. Accuracy assessment data form.

Accuracy Assessment Form for USGS-NPS Vegetation Mapping Program

Plot Number _____ Park _____ Date _____ Observers _____

Easting: _ _ _ _ _ _ E Northing _ _ _ _ _ _ _ N EPE/APE: _____ DOP: ____ Map datum: _____ Zone: ____

Topographic Description: _____ Elevation: _____ Aspect: _____ Canopy Closure: _____

Vegetation Association at Point: _____

Veg Assoc 1 w/in 50 m of point: _____

Veg Assoc 2 w/in 50 m of point: _____

Major Species by Strata:

_____

_____

Rationale for Classification:

_____

_____

_____

Comments:

_____

_____

Plot Number _____ Park _____ Date _____ Observers _____

Easting: _ _ _ _ _ _ E Northing _ _ _ _ _ _ _ N EPE/APE: _____ DOP: ____ Map datum: _____ Zone: ____

Topographic Description: _____ Elevation: _____ Aspect: _____ Canopy Closure: _____

Vegetation Association at Point: _____

Veg Assoc 1 w/in 50 m of point: _____

Veg Assoc 2 w/in 50 m of point: _____

Major Species by Strata:

_____

_____

Rationale for Classification:

_____

_____

_____

Comments:

_____

_____

Appendix F. Index of representative photographs of vegetation classification sampling plots in Fort Necessity National Battlefield.

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Northern Red Oak – Mixed Hardwood Forest

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Red Maple – Black Cherry Successional Forest

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Appendix G. Bibliography for global vegetation descriptions from the National Vegetation Classification System.

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As the nation's primary conservation agency, the Department of the Interior has responsibility for most of our nationally owned public land and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-200 April 2006

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