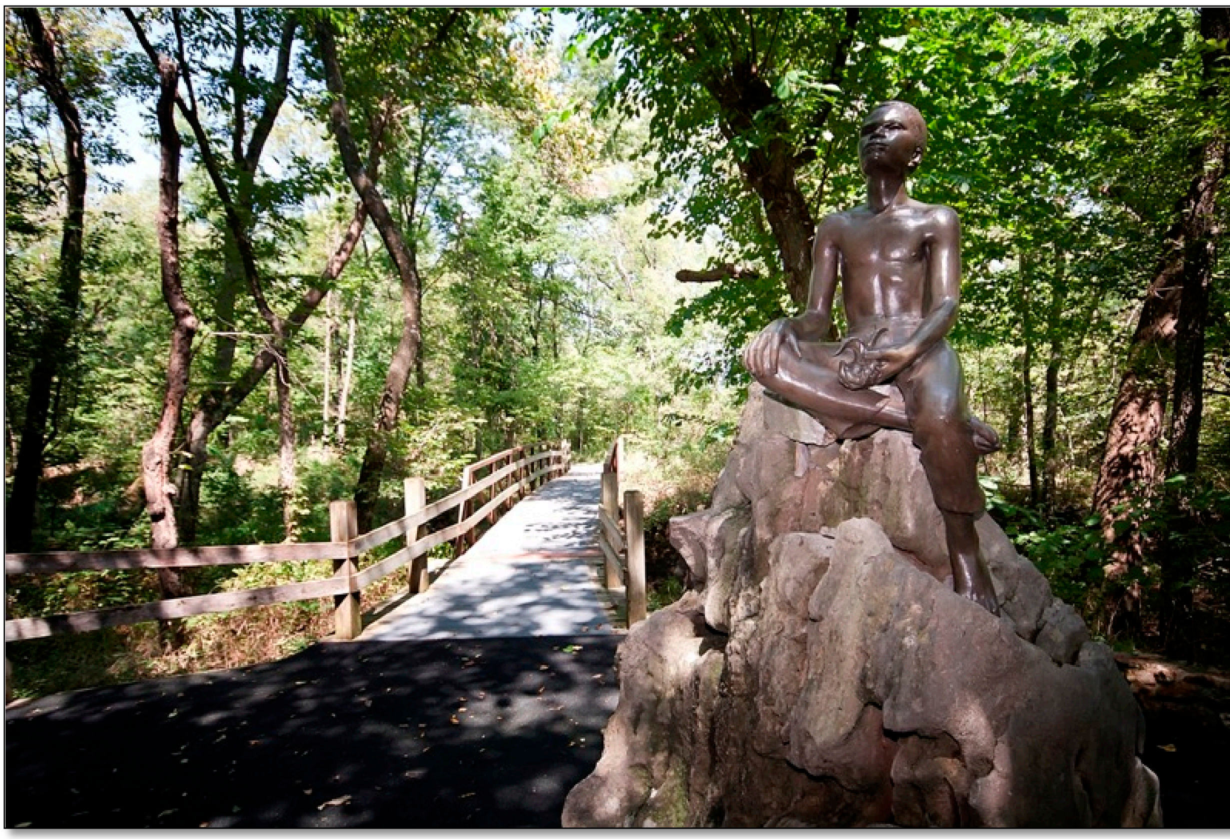
National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

# Vegetation Classification and Mapping of George Washington Carver National Monument

*Project Report*

Natural Resource Report NPS/GWCA/NRR—2013/648



**ON THE COVER**
Boy Carver Statue
Photograph by: Robert Amendola, Courtesy of George Washington Carver National Monument

# Vegetation Classification and Mapping of George Washington Carver National Monument

*Project Report*

Natural Resource Report NPS/GWCA/NRR—2013/648

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

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

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

*contact diamondd@missouri.edu

April 2013

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from Heartland Inventory & Monitoring Network (http://science.nature.nps.gov/im/units/htln/) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

Please cite this publication as:

Diamond, D. D., L. F. Elliott, M. D. DeBacker, K. M. James, D. L. Pursell, and A. Struckhoff. 2013. Vegetation mapping and classification of George Washington Carver National Monument. Natural Resource Report NPS/GWCA/NRR—2013/648. National Park Service, Fort Collins, Colorado.

NPS 397/120409, April 2013

# Contents

## Contents (continued)

# Figures

# Tables

## Abstract/Executive Summary

George Washington Carver National Monument (GWCA) is situated on the original Moses Carver homestead, where George Washington Carver spent about ten years of his early life. Although the plant communities were almost certainly highly disturbed during that time, Carver was positively influenced by the beauty and variety of his natural surroundings.

A vegetation classification and mapping project was initiated in 2010 and completed in 2012. Protocols and products were produced following National Park Service Vegetation Mapping Program guidelines. Classification was based on sixteen quantitative field plots, which were placed across GWCA in a stratified random manner based on qualitative field observation points and viewing of air photos. Mapping was based on photo-interpretation of both leaf-on and leaf-off air photos. Accuracy assessment points obtained during 2012 verified that the map is nearly 100% accurate.

Restored tallgrass prairie covers 134 acres (54.1 ha), or 57% of the park. An additional 54 acres (21.7 ha), or 23% of GWCA, is in ruderal woodland and forest. This type includes a central area that shades an interpretive trail along Carver Creek and Williams Branch, two perennial, spring-fed streams between the visitor's center and a replicated house similar to the one Carver lived in during part of his stay at the homestead. The remainder of the park is in early successional grassland or shrubland (27 acres or 11 ha or 11%) or is developed (22 acres or 8.87 ha or 9%).

# Introduction

## George Washington Carver National Monument Vegetation Mapping Project

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

The project was initiated because accurate maps of existing vegetation facilitate natural and cultural resource management and interpretation. GWCA offers opportunities for restoration of tallgrass prairie communities over deep, tillable soils, which are rare on the modern landscape. The natural landscapes, including woodlands and prairies, also influenced George Washington Carver in his youth, and thus were significant in serving as the basis for his lifelong interest in the natural world.

Each NPS Vegetation Mapping Inventory Project has three major components: classification, mapping, and map accuracy assessment. This report provides details on each of these fundamental elements.

## USGS-NPS Vegetation Mapping Program

The National Vegetation Inventory Program is an interagency initiative established to inventory, classify, describe, and map vegetation in National Park units and other areas across the United States. It is administered by the NPS Natural Resources Information Division, and provides baseline vegetation information to the NPS Inventory and Monitoring Program (I&M).

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

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

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

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

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

*Protocols*

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

*Standards*

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

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

### ***George Washington Carver National Monument***
The monument is located southwest of Joplin, MO (Figure 1) and consists of the original 237 acre Moses Carver homestead. The historic landscape probably consisted almost entirely of native grasslands or open savannas, with wetter grasslands along upland drainage ways (Annis et al. 2011). According to the Springs of Genius study (Harrington et al. 1999), by the 1860-1870s "the conversion of prairie to agricultural purposes would have been nearly complete…by the late 1870s there was probably very little uncompromised prairie left on the Carver farm. At least 100

acres had been developed as fields. The remaining open land was probably intensely grazed. … What prairie remained on the Carver farm would most likely have been restricted to fence rows, hedges and patches of marginal land used for pasture and hay production. These remnants would be significantly different from pre-settlement prairie, but because the composition of the pre-settlement prairie is unknown, the full extent of the changes cannot be determined."

In 1985, NPS began a restored tallgrass prairie program, and since then different methods have been used at different times to restore native grasses and forbs on former cropland areas. Management activities have included seeding, mowing, haying, and prescribed fire. Some areas purchased more recently have not yet been restored and consist of non-native grasses and forbs as well as successional woody species. Successional woodlands have also grown up adjacent to upland waterways. A man-made pond and small garden plot add diversity to the park. Invasive species, such as tall fescue (*Schedonorus phoenix*), smooth sumac (*Rhus glabra*), multiflora rose (*Rosa multiflora*), and Japanese honeysuckle (*Lonicera japonica*) are common (Annis et al. 2011). Several birds of continental concern are fairly common nesting species within the park, including the Dickcissel (*Spiza americana*), Indigo bunting (*Passerina cyanea*), and Carolina wren (*Thryothorus ludovicianus*) (Peitz et al. 2009). Streams also support high quality, diverse fish communities (Annis et al. 2011). A few significant prairie remnants remain in the general area of GWCA, and restored grasslands at the park may be valuable to a variety of native grassland flora and fauna.

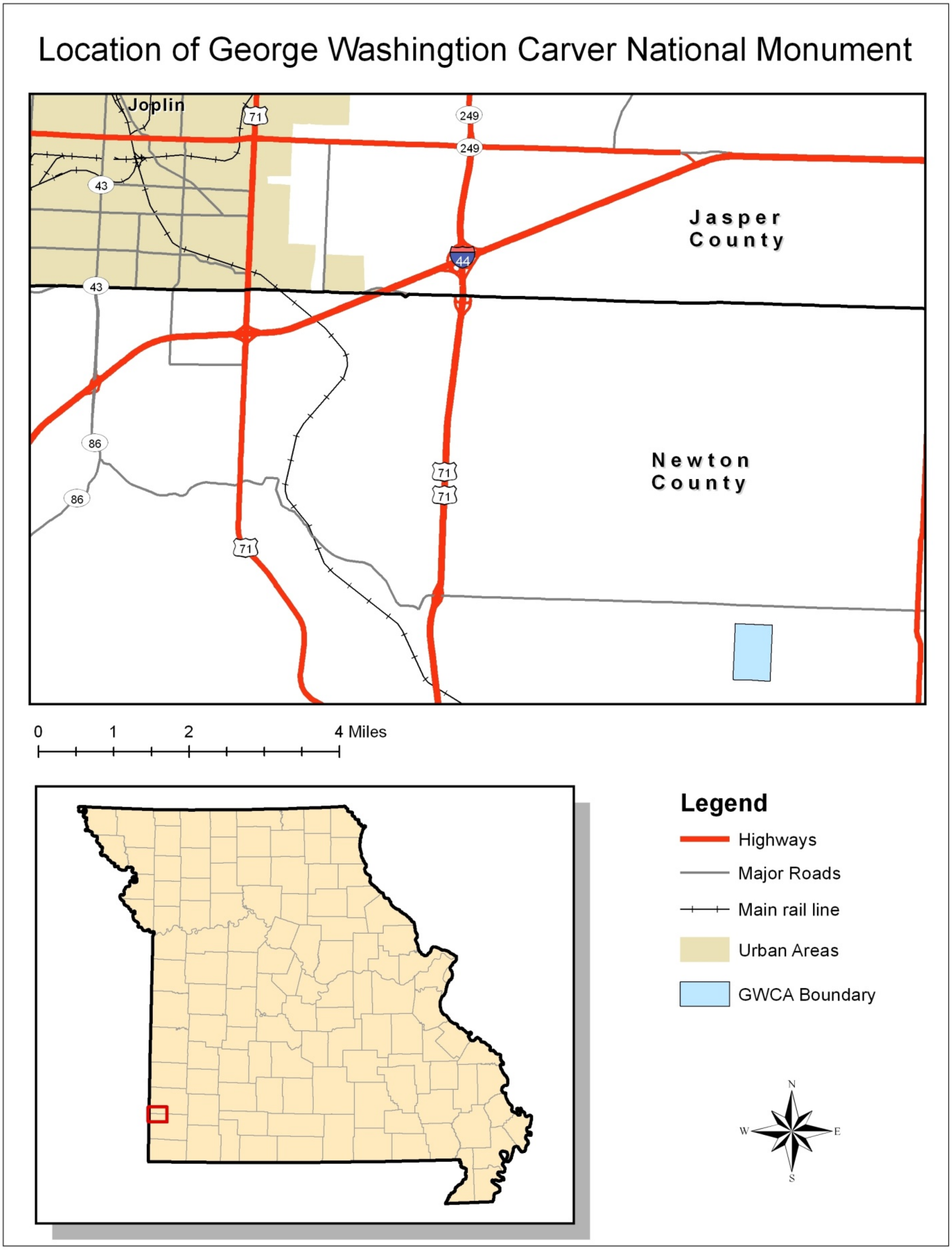



**Figure 1.** Location of George Washington Carver National Monument in Newton County, Missouri.

**Project Statistics**

Field Work Summer 2011:

Plot Sampling = 16

Plots sampled in June 2011 by MoRAP staff

Accuracy Assessment Points = 16

All collected in June 2012 by Heartland Inventory and Monitoring Network staff

Observation Points = 27

Collected between August 2009 and December 2010 by MoRAP staff

Classification:

1 NVC Plant Association
3 Park Special Vegetation Classes
1 Non-Vegetated Land-Use Class

GIS Database 2011 - 2012:

George Washington Carver National Monument = 237 acres (96 hectares)

Base Imagery used for mapping (acquired by MoRAP):

2009, Newton County, MO, leaf-on, true color, 1 m
2009, Newton County, MO, leaf-on, 3-band CIR, 1 m
2007-2009, Newton County, MO, true color, leaf-off, 2 foot

Additional Imagery acquired and viewed by MoRAP:

2007, Newton County, MO, leaf-on, true color, 1 m
2006, Newton County, MO, leaf-on, true color, 2 m
2005, Newton County, MO, leaf-on, true color, 2 m
2003, Newton County, MO, leaf-on, CIR, 1 m

Minimum Mapping Unit = 0.5 hectare
Minimum Patch Size=.007 hectares
Total Size = 38 Polygons
Average Polygon Size = 6.58 acres (2.66 hectares)
Overall Thematic Accuracy = 100%
Project Completion Date: 11/2012

# Methods

George Washington Carver National Monument, at 237 acres, is a small park as defined by sampling design protocols (TNC and ESRI 1994), so most of the mapped vegetation polygons were visited for this study. Since access to private lands outside of the park was not ensured, the project boundary consisted of the boundary of the park itself (Figure 2). Five major tasks were identified and completed, including:

1. Plan, gather data, and coordinate tasks;

2. Survey GWCA to understand and sample the vegetation;

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

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

5. Assess the accuracy of the final map product.

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

## Planning, Data Gathering, and Coordination

A Natural Resource Condition Assessment (NRCA) was completed for GWCA and published in 2011 (Annis et al. 2011). During the course of that project, the current vegetation mapping project was discussed with appropriate park staff in coordination with Heartland Network staff and MoRAP staff. A proposal for vegetation mapping was subsequently completed and approved by National Park Service National Vegetation Mapping staff. Based on that proposal, MoRAP was responsible for classification, plot sampling, mapping, and development of digital databases. The Heartland Network was responsible for oversight of MoRAP activities in concert with NPS Mapping Program staff, and coordinated Accuracy Assessment tasks. GWCA staff provided logistical and technical support, and helped coordinate field activities.

### *Field Survey*

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

A generalized land cover classification was available from the GWCA NRCA (Annis et al. 2011), and this information together with NAIP air photos, digital soils information, and field-collected observation data were used to inform the design of field surveys and ultimately vegetation classification and mapping (Figure 3). Observation points consisted of brief visits (fewer than 15 minute) by ecologists from MoRAP where general information on vegetation structure and composition was noted.

Vegetation data were collected at 16 plots by MoRAP staff in June of 2011 (Figure 4). In the lab, the locations of plots were randomly placed within the following general strata based on field observation points and viewing of air photos and digital soils surveys (available at http://soils.usda.gov/survey/geography/ssurgo/): woodland and forest over moist soils, woodland and forest over better-drained soils, shrubland and open woodland, restored prairie, and non-native fescue grassland. Plots were located >30 m from an obvious land cover edge, and for each point there was at least one alternate, should the original point be determined unusable in the field (e.g. close to an un-mapped trail or road, stand too small). The stratified random plot location information was loaded into a GPS and workers navigated to the plot in the field for field sampling.

Woodlands and forests were sampled with a 10 m x 40 m plot (400 sq m), shrublands and open woodlands with a 10 m x 20 m plot (200 sq m), and herbaceous vegetation with a 5 m x 20 m plot (100 sq m). Minimal flagging was used to mark the plot. Data were collected using a plot survey form (Appendix B). The survey form includes sections for plot location and description, as well as vegetation and environmental information about the plot.

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

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

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

**Table 1.** Canopy cover classes used for quantitative vegetation sampling.

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

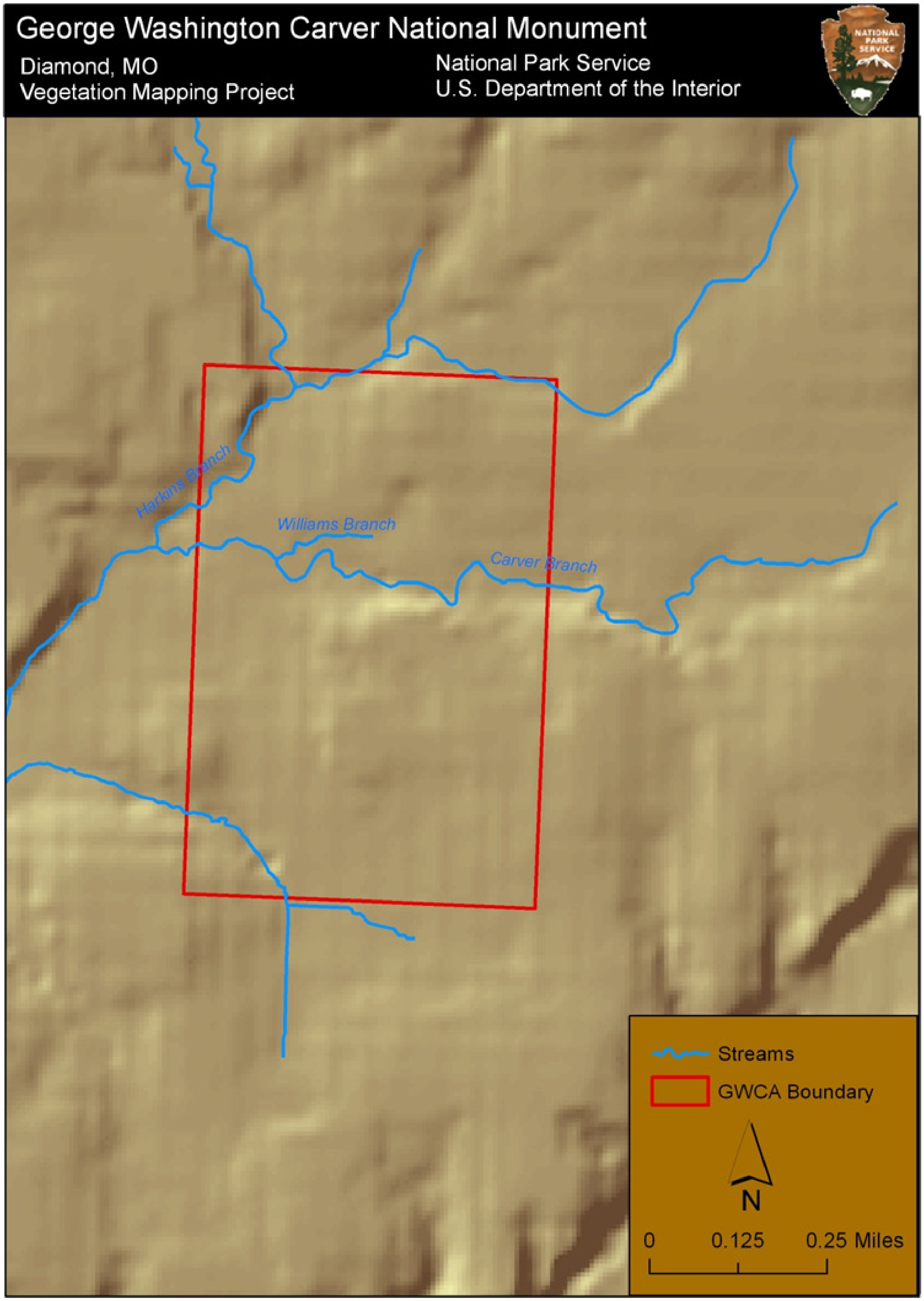



**Figure 2.** Map of the George Washington Carver National Monument.

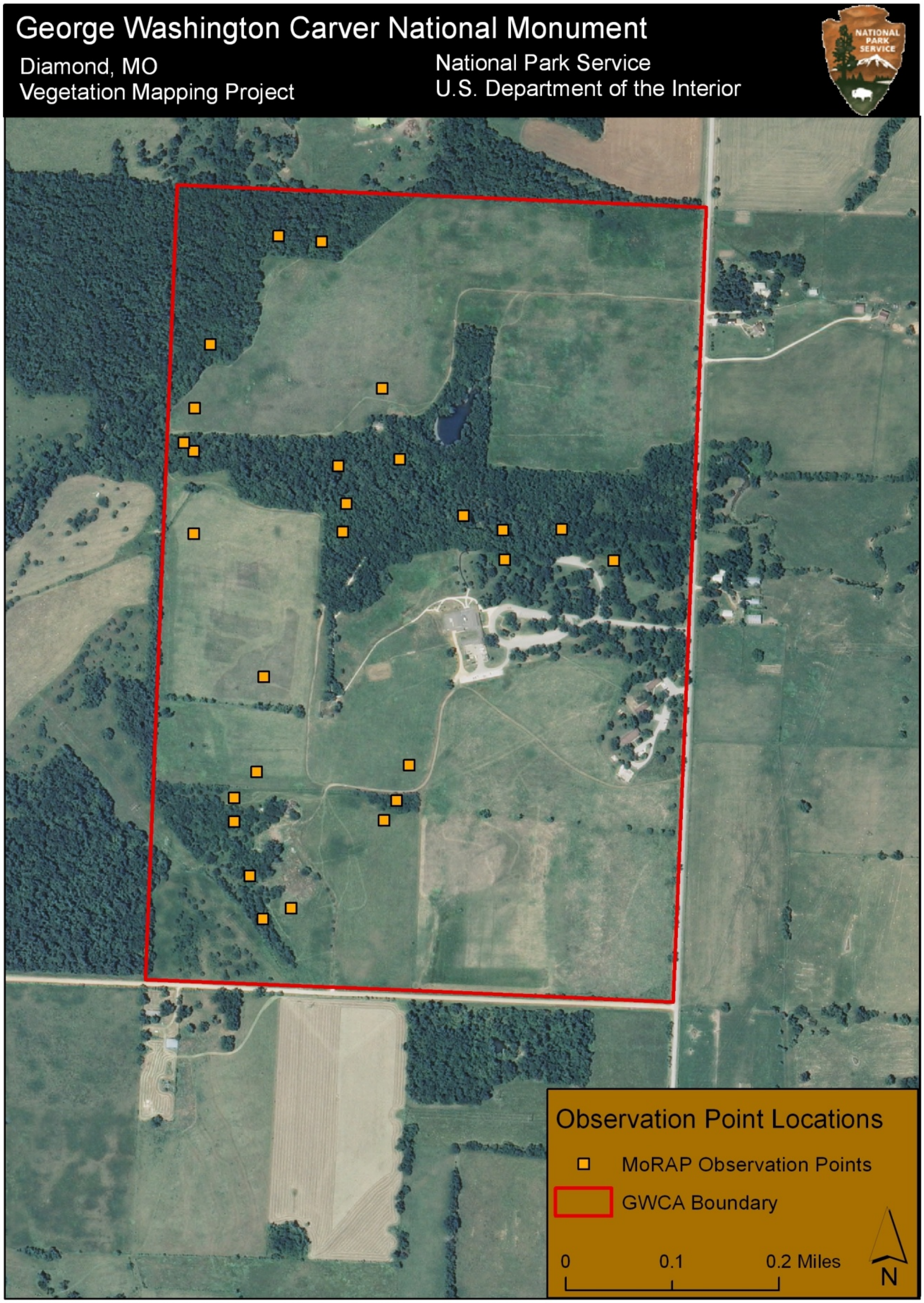



**Figure 3.** Location of 27 observation points collected in George Washington Carver National Monument.

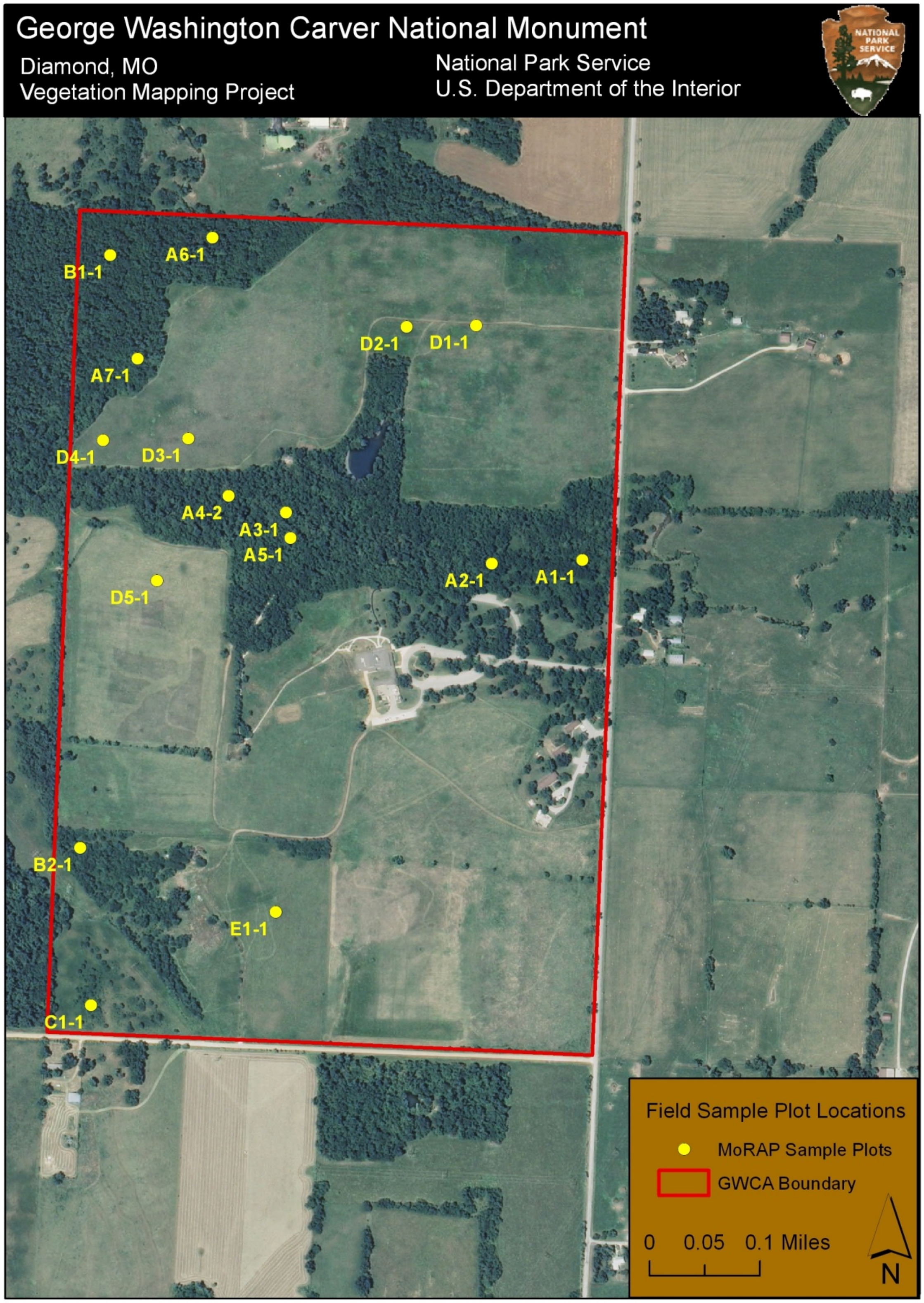



**Figure 4.** Location of 16 sampled plots within George Washington Carver National Monument.

### *Vegetation Classification*

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

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

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

.

Use of this formula reduces the effects of overlapping cover in various strata. We used a log transformation to standardize cover values using the formula log(cover + 1). Bray-Curtis dissimilarity was used as the distance metric for the cluster and ordination analyses (Legendre & Legendre 1998). Clustering was performed using the hierarchical clustering algorithm known as flexible Beta with a $\beta = -0.25$ (Lance & Williams 1966, Maechler et al. 2011). Non-metric multidimensional scaling was used to develop the ordination (Legendre & Legendre 1998, Roberts 2010).

Descriptive information on NVC community composition concepts and classification were obtained from the NatureServe Explorer (2012) website available at http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol. Where the observed GWCA vegetation did not fit descriptions of natural associations described for Missouri, ruderal types were assigned.

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

In the future, GWCA classification plot data may be used by NatureServe to update and improve world-wide (i.e., global) descriptions of the NVC plant associations, especially for ruderal types which are generally lacking for the Midwest. GWCA specific (i.e., local) descriptions were written based on GWCA plot, observation, and accuracy assessment data.

## Digital Imagery and Interpretation

The mapping component was produced by identifying land cover in a three-step process: (1) image objects were generated at 1 m resolution using e-Cognition applied to stacked leaf-on and leaf-off air photos, (2) image objects were coded with land cover classes on-screen, and (3) image objects were cut and corrected via heads-up digitizing at a display scale of not more than 1:1,000 against a back-drop of air photos. Imagery was the most recent available from the National Agriculture Imagery Program (NAIP; see http://www.fsa.usda.gov/Internet/FSA_File/naip_2009_info_final.pdf). This included 2009 leaf-on true color and 4-band Color infrared (CIR) 1 m resolution photos, and 2007-2009 leaf-off true color 2 foot resolution photos. All images were stacked before image objects were generated (Figure 5).

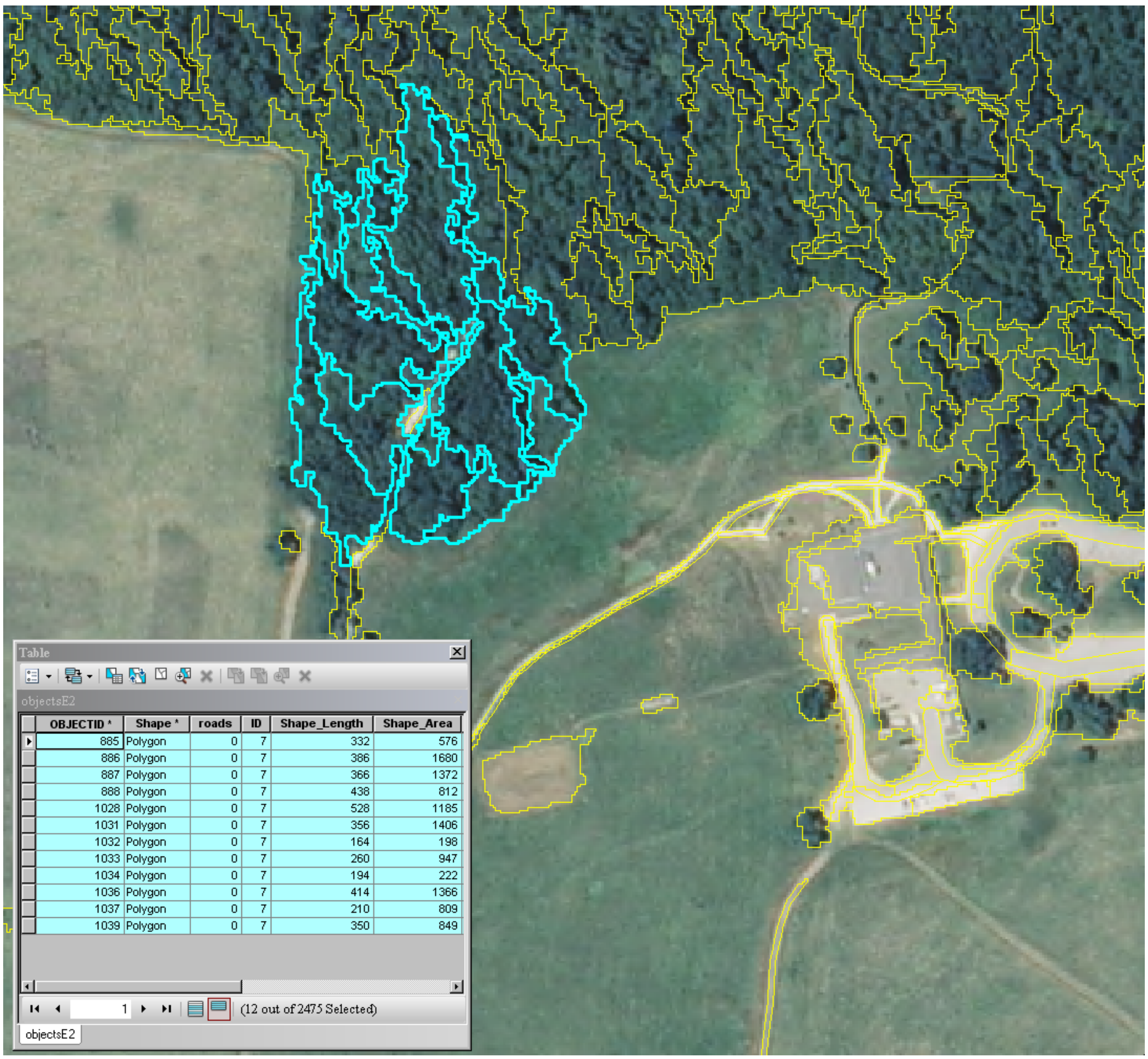



**Figure 5.** Example of polygon digitization process.

### *Accuracy Assessment*

Thematic accuracy assessment (AA) was conducted by the Heartland Inventory and Monitoring Network (HTLN). Methods and analysis for the accuracy assessment of vegetation mapping at George Washington Carver National Monument (GWCA) were based on National Park Service standards (Lea and Curtis 2010). Thematic or attribute accuracy of mapped vegetation classes were assessed independently following the completion of the vegetation mapping inventory by the lead authors. Representative sites were identified and visited in the field to determine if interpreted mapped classes were correctly assigned by field observers using the dichotomous key to mapped current vegetation types (Appendix C). Identifying the degree of correspondence between field observations and mapped attributes provides a measure of the maps suitability for different applications.

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

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

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

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

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

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

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

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

Field staff recorded plot size and shape, positional accuracy and vegetation classification at each point (Accuracy assessment field form, Appendix D). In addition, comments regarding the plot location, plot size and vegetation were recorded on the field form. Field data from the 16 points were entered into to the PLOTS database and underwent quality assurance/quality control (QA/QC) verification. In addition, the associated project geodatabase was updated in ArcGIS to reflect any changes to the point location due to offsets made in the field. All classification and spatial field observations were compared with the vegetation map and AA point locations for any differences.

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

**Table 3.** Summary of the Accuracy Assessment statistics used at George Washington Carver National Monument.

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

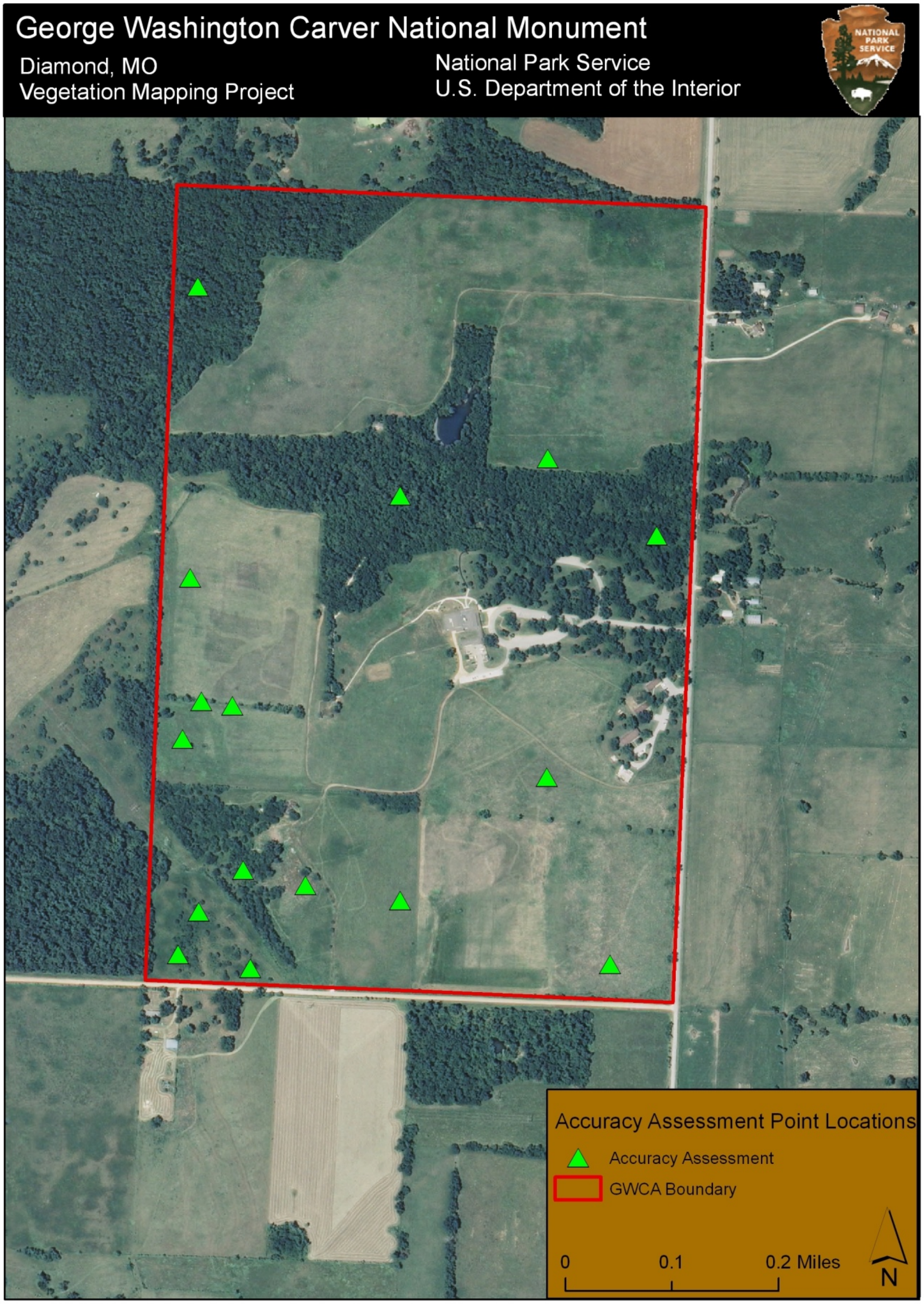
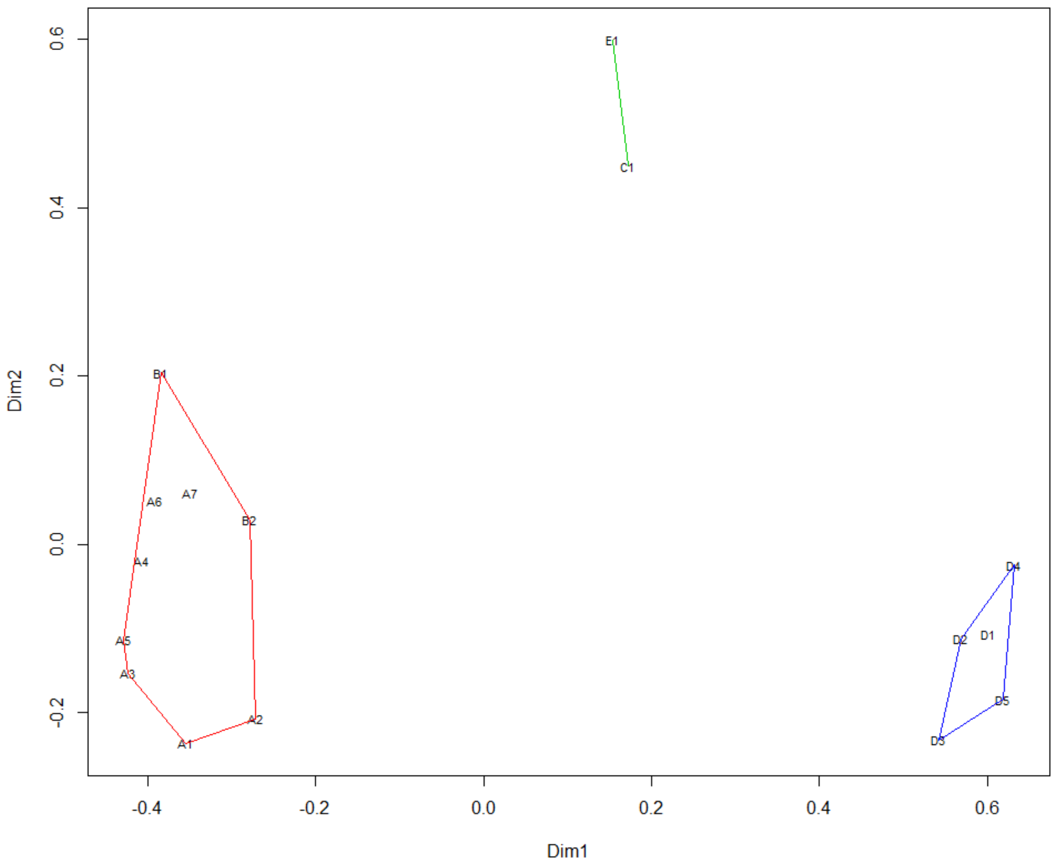



**Figure 6.** Accuracy Assessment points for George Washington Carver National Monument.

# Results

## Vegetation Classification

Four vegetation types were identified at GWCA based on ordination and cluster analysis results (**Figure 7**). Developed land, undivided by type, made up a fifth class. These results are generally in line with previous evaluations of the park (Annis et al. 2011, Jones 2004). Neither qualitative observation points nor quantitative plot data analysis supported the separation of a mesic prairie type from a drier type, as tentatively suggested by Jones (2004) and repeated by Annis et al. (2011). Sycamore (*Platanus occidentalis*) is a visually striking forest tree species with relatively large individuals adjacent to Carver Branch and to a lesser extent Harkins Branch. However, more mesic areas are usually not wider than 5 m from water's edge, and did not warrant sampling as a potentially separate forest type. During the sampling efforts a total of 171 taxa were recorded (Appendix E). A plant list provided by Jones (2004) listed 645 taxa, including 114 introduced species.



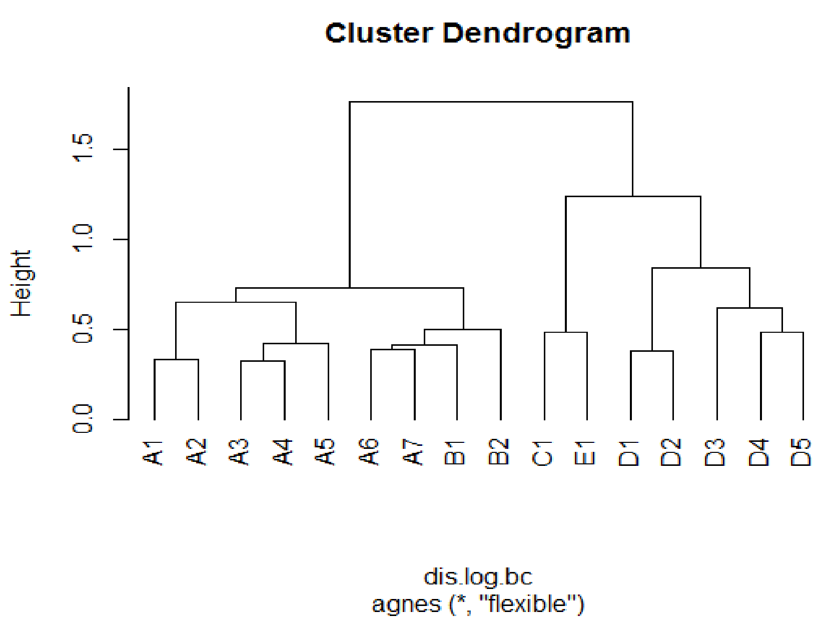




**Figure 7.** Ordination and cluster dendrogram for 16 plots sampled in George Washington Carver National Monument. Plots labeled A and B were assigned to a ruderal woodland and forest class, C was

in a ruderal shrubland class, D was restored tallgrass prairie plots, and E was a non-native ruderal grassland.

## Digital Imagery and Interpretation

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

### *Vegetation Map*

A total of 237 acres (96 hectares) are within the accepted boundaries of GWCA (Figure 8). The standard minimum mapping unit for NPS vegetation mapping projects is defined as 0.5 hectare, although several mapped polygons were smaller for GWCA. Restored tallgrass prairie made up most of the current vegetation of the park, and accounted for 134 acres (54.1 ha) in eight polygons, or 56.5% of the total area. Ruderal woodland and forest was the next most abundant with 53.6 acres in eight polygons, or 22.6% of the park. Non-native ruderal grassland and ruderal shrubland accounted for 25 acres (10.1 ha or 10.5%) and 2.2 acres (0.9 ha or <1%) of the area of the park, respectively. Developed land accounts for 21.9 acres (8.9 ha), or 9.2% of the park. A total of 36 polygons were mapped, with an average area of 15.2 acres (6.1 ha).

### *Accuracy Assessment*

The 2012 accuracy assessment for GWCA was limited to the 237 acres (96 hectares) within the park boundary. A total of 16 points were required to accurately evaluate the four natural vegetation map classes identified in the park.

Navigational error (positional accuracy) of the GPS unit ranged from 2 – 4 meters for the 16 accuracy assessment points. Only a single original point required a spatial offset to ensure the entire plot was composed of a homogenous map class. The new GPS coordinates for the offset were updated in both the project geodatabase as well as the tabular database.

**Table 4.** Mapped types identified at George Washington Carver National Monument.

| NVC Identifier | Mapped Type Name | Scientific Name / Description | Number of Polygons | Acres | Hectares |
|---|---|---|---|---|---|
| **Forest and Woodlands** | | | | | |
| None assigned | Ruderal Woodland and Forest | *Juglans nigra-Celtis occidentalis* Woodland and Forest | 8 | 53.63 | 21.7 |
| **Shrubland Vegetation** | | | | | |
| None assigned | Ruderal Shrubland | Early successional shrubs and small trees with non-native grasses | 7 | 2.2 | 0.89 |
| **Herbaceous Vegetation** | | | | | |
| CEGL004048 | Non-native Ruderal Grassland | *Schedonorus phoenix* Herbaceous Vegetation | 8 | 25.02 | 10.12 |

Table 5. Mapped types identified at George Washington Carver National Monument (continued).

| NVC Identifier | Mapped Type Name | Scientific Name / Description | Number of Polygons | Acres | Hectares |
|---|---|---|---|---|---|
| None assigned | Restored Tallgrass Prairie | *Andropogon gerardii - Sorghastrum nutans* Herbaceous Vegetation | 8 | 133.68 | 54.1 |
| **Land Use/Land Cover** | | | | | |
| None assigned | Developed Land | buildings, parking lots, picnic areas, roads, cemetery, garden, sewage application field | 4 | 21.92 | 8.87 |
| None assigned | Water | man-made, spring-fed pond | 1 | 0.54 | 0.22 |
| Total Land Use/Land Cover | | | 5 | 22.46 | 9.09 |
| Total Natural Vegetation | | | 31 | 214.53 | 86.81 |
| **Totals** | | | **36** | **236.99** | **95.9** |

Overall accuracy of the final error matrix was 100% for the natural vegetation map classes at GWCA (Appendix A). All four natural vegetation map classes fell into sampling scenario E, thus occurring both in low frequency and low abundance on the park. Each type was readily discernible in the field using the dichotomous key.

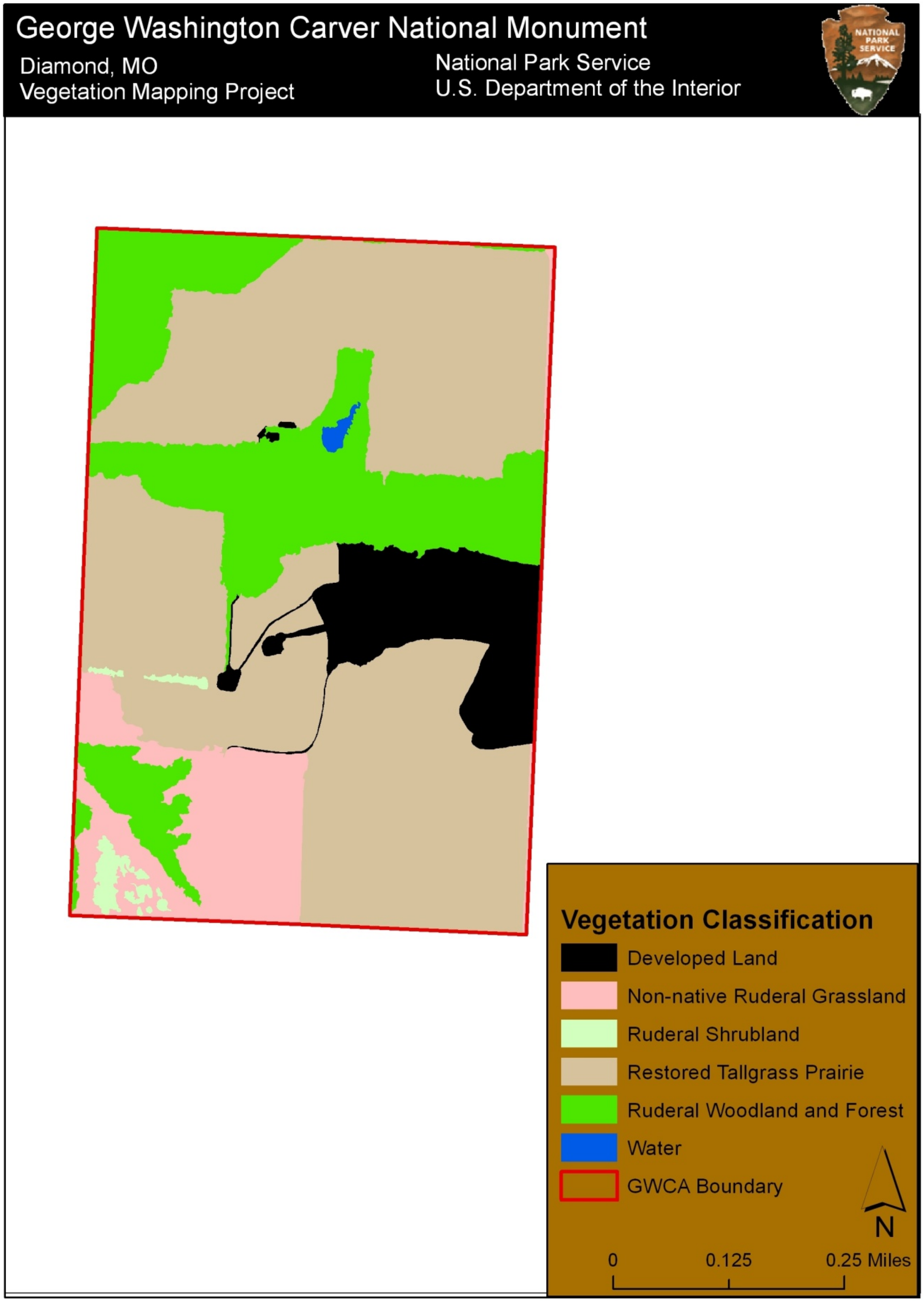



**Figure 8.** Vegetation map of George Washington Carver National Monument.

# Vegetation Associations

***Mapped Type Name: Ruderal Woodland and Forest***
**Macrogroup:** Eastern North American Ruderal Forest and Plantation (MG013)
**Group:** North & Central Hardwood & Conifer Ruderal Forest Group (G030)
**Association:** None assigned
**Type Common Name:** BlackWalnut-Common Hackberry Woodland and Forest
**Type Scientific Name:** *Juglans nigra –Celtis occidentalis* Woodland and Forest

**Figure 9.** Ruderal Woodland and Forest at George Washington Carver National Monument.

**Global Summary:** Ruderal woodlands and forests of moist soils in the Midwest often contain black walnut (*Juglans nigra*) and common hackberry (*Celtis occidentalis*) among the dominant species. However, these types of successional communities have not been well-described within the National Vegetation Classification. Other species common on disturbed bottomlands include red mulberry (*Morus rubra*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), sycamore (*Platanus occidentalis*), and slippery elm (*Ulmus rubra*) (Figure 9).

**Environmental Description:** At GWCA, this type was mainly on soils of headwater or spring-fed drainages, although they are generally only temporarily, rather than seasonally flooded.

These areas have mainly been plowed for row crop production or at least cleared for grazing or other land uses in the past. A small area in the far northwestern side of the park has better-drained soils according to county soil surveys.

**Vegetation Description:** Early successional and invasive species were characteristic of this type. Black walnut (*Juglans nigra*), common hackberry (*Celtis occidentalis*), slippery elm (*Ulmus rubra*), American ash (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), Osage orange (M*aclura pomifera*), and honeylocust (*Gleditsia triacanthos*) were often important. Coralberry (*Symphoricarpos orbiculatus*) and multiflora rose (*Rosa multiflora*) were common shrubs, and Virginia creeper (*Pathenocissu quinquefolia*) and poison ivy (*Toxicodendron radicans*) were common vines. Japanese honeysuckle (*Lonicera japonica*) formed a mat on the forest floor in some locations, and other non-native invasive species such as winter creeper (*Euonymus fortunei*), bromes (*Bromus tectorum, B. arvensis*), ground ivy (*Glechoma hederacea*), and tall fescue (*Schedonorus phoenix*) were locally dominant ground flora. Communities along Carver Creek and Williams Branch in the central part of the park had more large trees versus other areas, and sycamore (*Platanus occidentalis*) formed an aesthetically pleasing gallery of large trees at water's edge in some places. Succession in this area may lead to more mature forests that fit within the NVC *Fraxinus pennsylvanica – Celtis* spp.-*Quercus* spp.-*Platanus occidentalis* Bottomland Forest (CEGL002410) over the next few decades. Communities in the southwest portion of GWCA appear more disturbed with fewer large trees and a more open canopy versus other woodlands, and eastern redcedar (*Juniperus virginiana*) was more common (Table 6).

Most Abundant Species:

**Table 6.** Average cover (for plots where the species occurred) and frequency by layer and species for nine plots taken within Ruderal Woodland and Forest. Only species with at least 0.5% cover in at least two plots are shown.

| **Ruderal Woodland and Forest** | | | |
|---|---|---|---|
| **Scientific Name** | **Common Name** | **%Cover** | **Frequency** |
| Tree | | | |
| *Juglans nigra* | black walnut | 40.46 | 88.9% |
| *Celtis occidentalis* | common hackberry | 36.65 | 100.0% |
| *Maclura pomifera* | Osage orange | 20.41 | 55.6% |
| *Platanus occidentalis* | sycamore | 9.00 | 22.2% |
| *Ulmus rubra* | slippery elm | 4.59 | 88.9% |
| *Gleditsia triacanthos* | honey locust | 4.32 | 66.7% |
| *Quercus muehlenbergii* | chinkapin oak | 4.23 | 44.4% |
| *Quercus macrocarpa* | bur oak | 2.33 | 33.3% |
| *Morus rubra* | red mulberry | 1.57 | 77.8% |
| *Prunus serotina* | black cherry | 1.50 | 66.7% |
| *Fraxinus pennsylvanica* | green ash | 1.50 | 33.3% |
| *Juniperus virginiana* | eastern redcedar | 1.13 | 44.4% |
| *Robinia pseudoacacia* | black locust | 1.00 | 11.1% |
| *Ulmus americana* | American elm | 0.60 | 55.6% |
| *Acer negundo* | boxelder | 0.50 | 33.3% |

**Table 5.** Average cover (for plots where the species occurred) and frequency by layer and species for nine plots taken within Ruderal Woodland and Forest. Only species with at least 0.5% cover in at least two plots are shown (continued).

| Scientific Name | Common Name | %Cover | Frequency |
|---|---|---|---|
| Shrub | | | |
| *Symphoricarpos orbiculatus* | coralberry | 24.56 | 88.9% |
| *Euonymus fortunei* | winter creeper | 10.38 | 44.4% |
| *Pathenocissus quinquefolia* | Virginia creeper | 8.78 | 100.0% |
| *Rosa multiflora* | multiflora rose | 6.56 | 88.9% |
| *Toxicodendron radicans* | poison ivy | 5.73 | 77.8% |
| *Smilax bona-nox* | saw greenbrier | 4.42 | 77.8% |
| *Prunus hortulana* | hortulan plum | 3.49 | 11.1% |
| *Vitis vulpina* | frost grape | 3.11 | 88.9% |
| *Ribes missouriense* | Missouri gooseberry | 2.29 | 77.8% |
| *Smilax tamnoides* | bristly greenbrier | 1.39 | 100.0% |
| *Vitis aestivalis* | summer grape | 0.50 | 55.6% |
| *Cercis canadensis* | eastern redbud | 0.50 | 33.3% |
| *Sideroxylon lanuginosum* | gum bully | 0.50 | 33.3% |
| *Viburnum rufidulum* | rusty blackhaw | 0.50 | 22.2% |
| Herbaceous | | | |
| *Bromus tectorum* | cheatgrass | 53.33 | 33.3% |
| *Lonicera japonica* | Japanese honeysuckle | 33.50 | 55.6% |
| *Elymus virginicus* | Virginia wildrye | 23.25 | 88.9% |
| *Sanicula canadensis* | Canadian blacksnakeroot | 15.00 | 11.1% |
| *Chasmanthium latifolium* | Indian woodoats | 12.00 | 44.4% |
| *Bromus arvensis* | field brome | 6.17 | 33.3% |
| *Carex jamesii* | James' sedge | 3.00 | 22.2% |
| *Silphium perfoliatum* | cup plant | 3.00 | 22.2% |
| *Glechoma hederacea* | ground ivy | 3.00 | 11.1% |
| *Muhlenbergia sobolifera* | rock muhly | 3.00 | 11.1% |
| *Schedonorus phoenix* | tall fescue | 3.00 | 11.1% |
| *Solidago gigantea* | giant goldenrod | 3.00 | 11.1% |
| *Dichanthelium clandestinum* | deertongue | 2.94 | 100.0% |
| *Elephantopus carolinianus* | Carolina elephantsfoot | 1.75 | 88.9% |
| *Asplenium platyneuron* | ebony spleenwort | 1.75 | 22.2% |
| *Festuca subverticillata* | nodding fescue | 1.50 | 55.6% |
| *Desmodium perplexum* | perplexed ticktrefoil | 1.33 | 33.3% |
| *Polygonum virginianum* | jumpseed | 1.13 | 44.4% |
| *Ageratina altissima* | white snakeroot | 0.92 | 66.7% |

**Table 5.** Average cover (for plots where the species occurred) and frequency by layer and species for nine plots taken within Ruderal Woodland and Forest. Only species with at least 0.5% cover in at least two plots are shown (continued).

| **Scientific Name** | **Common Name** | **%Cover** | **Frequency** |
|---|---|---|---|
| *Sanicula odorata* | clustered blacksnakeroot | 0.86 | 77.8% |
| *Carex blanda* | eastern woodland sedge | 0.50 | 100.0% |
| *Phryma leptostachya* | American lopseed | 0.50 | 88.9% |
| *Geum canadense* | white avens | 0.50 | 77.8% |
| *Viola sororia* | common blue violet | 0.50 | 77.8% |
| *Ambrosia trifida* | great ragweed | 0.50 | 66.7% |
| *Geum vernum* | spring avens | 0.50 | 66.7% |
| *Leersia virginica* | whitegrass | 0.50 | 66.7% |
| *Ruellia strepens* | limestone wild petunia | 0.50 | 66.7% |
| *Conyza canadensis* | Canadian horseweed | 0.50 | 55.6% |
| *Carex amphibola* | eastern narrowleaf sedge | 0.50 | 4.4% |
| *Poa sylvestris* | woodland bluegrass | 0.50 | 44.4% |
| *Verbesina virginica* | white crownbeard | 0.50 | 44.4% |
| *Impatiens* spp. | touch-me-not | 0.50 | 33.3% |
| *Phytolacca americana* | American pokeweed | 0.50 | 33.3% |
| *Silene stellata* | widowsfrill | 0.50 | 33.3% |
| *Verbesina alternifolia* | wingstem | 0.50 | 33.3% |
| *Arisaema dracontium* | green dragon | 0.50 | 22.2% |
| *Bromus pubescens* | hairy woodland brome | 0.50 | 22.2% |
| *Cryptotaenia canadensis* | Canadian honewort | 0.50 | 22.2% |
| *Dactylis glomerata* | orchardgrass | 0.50 | 22.2% |
| *Desmodium paniculatum* | panicledleaf ticktrefoil | 0.50 | 22.2% |
| *Erigeron strigosus* | prairie fleabane | 0.50 | 22.2% |
| *Galium aparine* | stickywilly | 0.50 | 22.2% |
| *Lactuca floridana* | woodland lettuce | 0.50 | 22.2% |
| *Osmorhiza claytonii* | Clayton's sweetroot | 0.50 | 22.2% |
| *Pilea pumila* | Canadian clearweed | 0.50 | 22.2% |
| *Trillium sessile* | toadshade | 0.50 | 22.2% |
| *Vernonia baldwinii* | Baldwin's ironweed | 0.50 | 22.2% |
| *Viola pubescens* var. *pubescens* | downy yellow violet | 0.50 | 22.2% |

***Mapped Type Name: Ruderal Shrubland***
**Macrogroup:** Eastern Ruderal Shrubland and Grassland (MG123)
**Group:** Eastern Ruderal Shrubland and Grassland (G059)
**Association:** None assigned
**Type Common Name:** Ruderal Shrubland
**Type Scientific Name:** Early Successional shrubs and small trees with non-native grasses

**Figure 10.** Ruderal Shrubland at George Washington Carver National Monument.

**Global Summary:** Ruderal shrublands occur throughout the Midwest, but have not been described and included within the National Vegetation Classification. The extent of this type on the landscape is not clear. Open lands in the region are largely used for pasture, and efforts are made to suppress woody species. Thus, this type could be relatively uncommon in the modern landscape.

**Environmental Description:** At George Washington Carver National Monument these areas were former cropland that were converted to pasture with subsequent invasion of woody species, or may represent re-vegetation of soils disturbed by past small-scale mining. This type occurs on former prairie soils (Figure 10).

**Vegetation Description:** This shrubland was dominated by weedy and early successional species such as Osage orange (*Maclura pomifera*), honeylocust (*Gleditsia triacanthos*), hortulan plum species (*Prunus hortulana*), and Pennsylvania blackberry (*Rubus pensilvanicus*). Non-native tall fescue (*Schedonorus phoenix*) together with annual and short-lived perennial grasses and forbs such as field brome (*Bromus arvensis*) and Canada germander (*Teucrium canadense*) were common (Table 7).

Most Abundant Species:

**Table 7.** Percent cover for species found in one plot sampled for Ruderal Shrubland.

| **Ruderal Shrubland** | | |
|---|---|---|
| **Scientific Name** | **Common Name** | **%Cover** |
| Shrub | | |
| *Maclura pomifera* | Osage orange | 39.375 |
| *Gleditsia triacanthos* | honey locust | 3.485 |
| *Symphoricarpos orbiculatus* | coralberry | 15 |
| *Prunus hortulana* | hortulan plum | 15 |
| *Rubus pensilvanicus* | Pennsylvania blackberry | 15 |
| Herbaceous | | |
| *Schedonorus phoenix* | tall fescue | 37.5 |
| *Bromus arvensis* | field brome | 3 |
| *Teucrium canadense* | Canada germander | 3 |
| *Vernonia baldwinii* | Baldwin's ironweed | 0.5 |
| *Lactuca floridana* | woodland lettuce | 0.5 |
| *Achillea millefolium* | common yarrow | 0.5 |
| *Allium vineale* | wild garlic | 0.5 |
| *Andropogon virginicus* | broomsedge bluestem | 0.5 |
| *Carex bushii* | Bush's sedge | 0.5 |
| *Cirsium altissimum* | tall thistle | 0.5 |
| *Conyza canadensis* | Canadian horseweed | 0.5 |
| *Dactylis glomerata* | orchardgrass | 0.5 |
| *Dianthus armeria* | Deptford pink | 0.5 |
| *Dichanthelium clandestinum* | deertongue | 0.5 |
| *Erigeron strigosus* | prairie fleabane | 0.5 |
| *Trifolium pratense* | red clover | 0.5 |
| *Verbascum blattaria* | moth mullein | 0.5 |
| *Ambrosia artemisiifolia* | annual ragweed | 0.5 |
| *Galium virgatum* | limestone bedstraw | 0.5 |
| *Trifolium campestre* | field clover | 0.5 |
| *Solanum carolinense* | Carolina horsenettle | 0.5 |
| *Tridens flavus* | purpletop tridens | 0.5 |

***Mapped Type Name: Non-native Ruderal Grassland***
**Macrogroup:** Eastern Ruderal Shrubland and Grassland (MG123)
**Group:** Eastern Ruderal Shrubland and Grassland (G059)
**Association:** CEGL004048
**NVC Common Name:** (Tall Fescue, Meadow Fescue) Herbaceous Vegetation
**NVC Scientific Name:** *Schedonorus (phoenix, pratensis)* Herbaceous Vegetation

**Figure 11.** Non-native Ruderal Grassland at George Washington Carver National Monument.

**Global Summary:** This association (Figure 11) includes grassland pastures and hayfields, more-or-less cultural, though sometimes no longer actively maintained. The dominant species in this type are the European "tall or meadow fescues" of uncertain and controversial generic placement. Several other exotic grasses (redtop (*Agrostis gigantea),* orchardgrass *(Dactylis glomerata),* common velvetgrass (*Holcus lanatus),* timothy (*Phleum pretense)*, and Kentucky bluegrass (*Poa pratensis)*, for example) are common associates. These communities are sometimes nearly monospecific but can also be very diverse and contain many native as well as exotic species of grasses, sedges, and forbs. Exotic forbs include the legumes sericea lespedeza (*Lespedeza cuneata),* field clover (*Trifolium campestre),* alsike clover (*Trifolium hybridum),* red clover (*Trifolium pretense)*, and white clover (*Trifolium repens)*, as well as common yarrow (*Achillea millefolium),* hedge false bindweed (*Calystegia sepium),* Queen Anne's lace *(Daucus* *carota),* oxeye daisy (*Leucanthemum vulgare),* common yellow oxalis (*Oxalis stricta)*, and narrowleaf plantain (*Plantago lanceolata)*. Common native herbs include Indianhemp (*Apocynum cannabinum),* hoary ticktrefoil (*Desmodium canescens),* deertongue (*Dichanthelium clandestinum),* eastern daisy fleabane (*Erigeron annuus),* Virginia strawberry (*Fragaria virginiana),* common cinquefoil (*Potentilla simplex),* Carolina horsenettle (*Solanum carolinense),* Canada goldenrod (*Solidago canadensis)*, and yellow crownbeard (*Verbesina occidentalis*). This vegetation is currently defined for the central and southern Appalachians, Ozarks, Ouachita Mountains, and parts of the Piedmont and Interior Low Plateau, but it is possible throughout much of the eastern United States and southern Canada.

**Environmental Description:** This association at GWCA includes former grassland pastures and hayfields, more-or-less cultural, though no longer actively maintained. It occurred in areas that have been cleared in the past, including abandoned farmlands, small scale mines and associated tailings, and other areas disturbed by human activities.

**Vegetation Description:** This mapped vegetation type was dominated by tall fescue (*Schedonorus phoenix*), which was often the overwhelming dominant, and other successional grasses and forbs. Ruderal shrubs and small trees were often present, including Pennsylvania blackberry (*Rubus pensilvanicus*), hortulan plum (*Prunus hortulana*), multiflora rose (*Rosa multiflora*), honeylocust (*Gleditsia triacanthos*), and Osage orange (*Maclura pomifera*) (Table 8).

Most Abundant Species:

**Table 8.** Percent cover for species found in one plot sampled for Non-native Ruderal Grassland.

| **Non-native Ruderal Grassland** | | |
|---|---|---|
| **Scientific Name** | **Common Name** | **%Cover** |
| Tree | | |
| *Gleditsia triacanthos* | honey locust | 3 |
| Shrub | | |
| *Symphoricarpos orbiculatus* | coralberry | 3 |
| *Rubus pensilvanicus* | Pennsylvania blackberry | 0.5 |
| *Prunus hortulana* | hortulan plum | 0.5 |
| *Maclura pomifera* | Osage orange | 0.5 |
| *Rosa multiflora* | multiflora rose | 0.5 |
| Herbaceous | | |
| *Schedonorus phoenix* | tall fescue | 85 |
| *Vernonia baldwinii* | Baldwin's ironweed | 0.5 |
| *Vicia sativa* | garden vetch | 0.5 |
| *Vernonia arkansana* | Arkansas ironweed | 0.5 |
| *Trifolium pretense* | red clover | 0.5 |
| *Tridens flavus* | purpletop tridens | 0.5 |

**Table 9.** Percent cover for species found in one plot sampled for Non-native Ruderal Grassland. (continued)

| Non-native Ruderal Grassland | | |
|---|---|---|
| **Scientific Name** | **Common Name** | **%Cover** |
| *Teucrium canadense* | Canada germander | 0.5 |
| *Solanum carolinense* | Carolina horsenettle | 0.5 |
| **Scientific Name** | **Common Name** | **%Cover** |
| *Andropogon virginicus* | broomsedge bluestem | 0.5 |
| *Erechtites hieraciifolia* | American burnweed | 0.5 |
| *Desmodium paniculatum* | panicleleaf tickrefoil | 0.5 |
| *Desmodium glabellum* | Dillenius' ticktrefoil | 0.5 |
| *Croton monanthogynus* | prairie tea | 0.5 |
| *Cirsium altissimum* | tall thistle | 0.5 |

***Mapped Type Name: Restored Tallgrass Prairie***

**Macrogroup:** Planted to replicate – Great Plains Tallgrass Prairie, Savanna & Shrubland (MG054)

**Group:** Planted to replicate – Central Great Plains Tallgrass Prairie Group (G333)

**Association:** None assigned

**Type Common Name:** Big Bluestem – Indiangrass Herbaceous Vegetation

**Type Scientific Name:** *Andropogon gerardii – Sorghastrum nutans* Herbaceous Vegetation

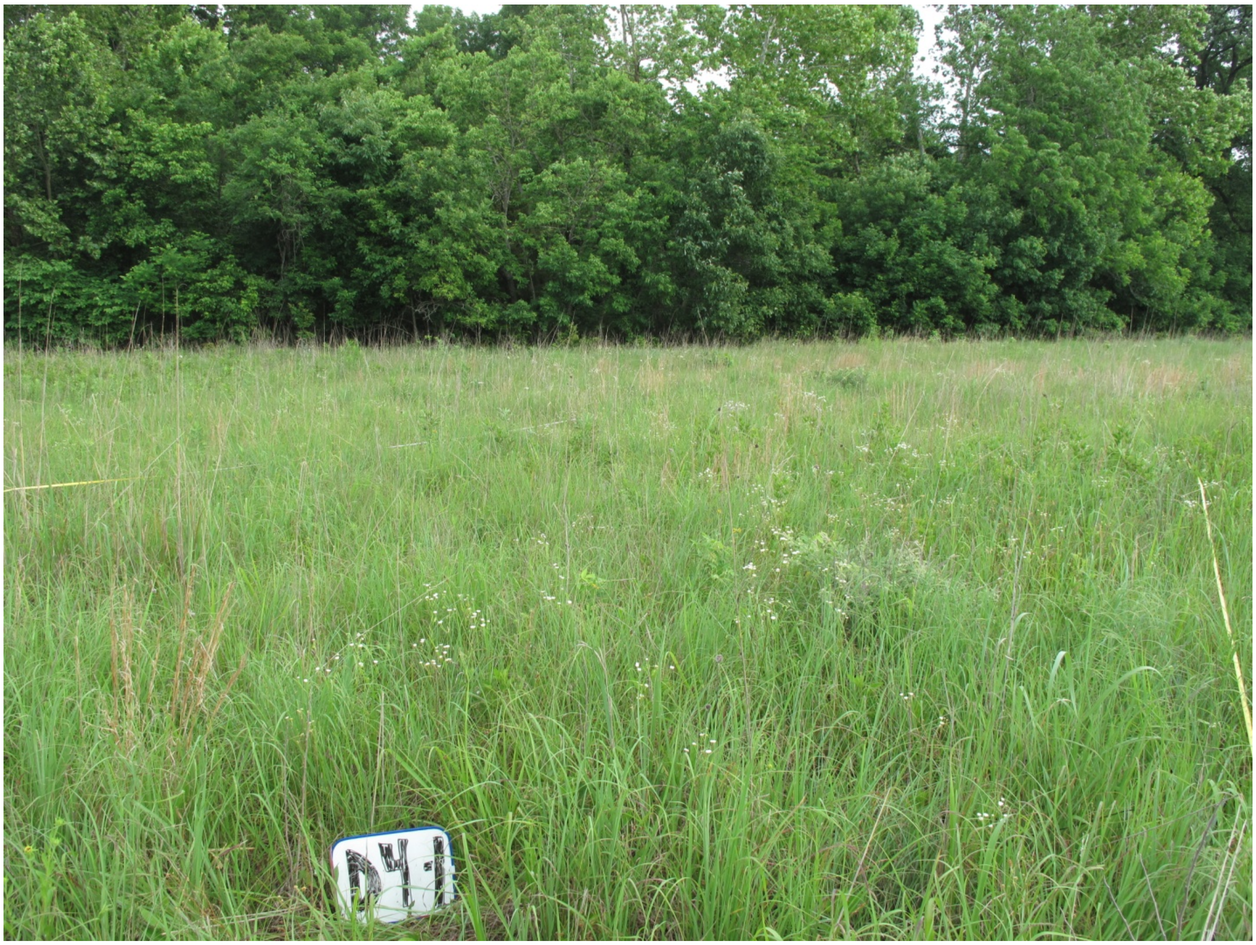


**Figure 12.** Restored Tallgrass Prairie at George Washington Carver National Monument.

**Global Summary:** This community (Figure 12) is typical of restored tallgrass prairie plots throughout the Midwest. Both native and non-native grasses and forbs may volunteer in. Efforts are often on-going and uneven, with managers adding native forbs or grasses in an ad hoc fashion. The general aspect or restorations is of a tallgrass prairie with the flowering culms of visual dominants often reaching 2 m tall, but prairie forbs are often lacking or may be present in novel proportions (**Error! Reference source not found.**). Weedy shrubs and vines such as blackberry (*Rubus* spp.) and sumac (*Rhus* spp.) are nearly always present in prairie restorations.

**Environmental Description:** This community at GWCA occurs on old cropland. Some areas are more moist than others, though differences apparent in the field were subtle.

**Vegetation Description:** This grassland community was usually dominated by native tallgrass prairie species such as big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*). Restoration efforts have not been uniformly successful, and in some patches, usually <500 square meters, shrubs and annual grasses were among the dominants. Field brome (*Bromus arvensis*) was commonly important in these patches. Shrubs, including Pennsylvania blackberry (*Rubus pensilvanicus*) and sumac (*Rhus copallinum* and *Rhus glabra*) were common components, and were among the visual dominants in some patches after one or more years of rest following mowing or prescribed fire. A wide variety of other herbaceous species were present, including rush (*Juncus* spp.) and sedge (*Carex* spp.) species, composite dropseed (*Sporobolus compositus*), and blackeyed Susan (*Rudbeckia hirta*). The herbaceous flora varied based on soil characteristics and, apparently, on past restoration history, which was not perfectly documented (Table 10).

<u>Most Abundant Species:</u>

**Table 10**. Average cover (for plots where the species occurred) and frequency by layer and species for five plots taken within Restored Tallgrass Prairie. Only species with at least 0.5% cover in at least two plots are shown.

| **Restored Tallgrass Prarie** | | | |
|---|---|---|---|
| **Scientific Name** | **Common Name** | **%Cover** | **Frequency** |
| Tree | | | |
| *Fraxinus pennsylvanica* | green ash | 17.55 | 20% |
| Shrub | | | |
| *Rhus copallinum* | winged sumac | 13.67 | 60% |
| *Rubus pensilvanicus* | Pennsylvania blackberry | 2.50 | 100% |
| *Prunus americana* | American plum | 0.50 | 40% |
| Herbaceous | | | |
| *Bromus arvensis* | field brome | 37.50 | 40% |
| *Andropogon gerardii* | big bluestem | 31.10 | 100% |
| *Sporobolus compositus* var. *compositus* | composite dropseed | 26.25 | 40% |
| *Trifolium campestre* | field clover | 11.00 | 60% |
| *Sorghastrum nutans* | Indian grass | 9.70 | 100% |
| *Schizachyrium scoparium* | little bluestem | 8.40 | 100% |
| *Agrostis hyemalis* | winter bentgrass | 5.33 | 60% |
| *Juncus tenuis* | poverty rush | 4.13 | 80% |
| *Andropogon virginicus* | broomsedge bluestem | 3.00 | 20% |
| *Poa annua* | annual bluegrass | 3.00 | 20% |
| *Solidago altissima* | Canada goldenrod | 3.00 | 20% |
| *Tridens flavus* | purpletop tridens | 2.17 | 60% |
| *Ambrosia artemisiifolia* | annual ragweed | 1.75 | 40% |

**Table 8.** Average cover (for plots where the species occurred) and frequency by layer and species for five plots taken within Restored Tallgrass Prairie. Only species with at least 0.5% cover in at least two plots are shown (continued).

| **Restored Tallgrass Prarie** | | | |
|---|---|---|---|
| **Scientific Name** | **Common Name** | **%Cover** | **Frequency** |
| *Carex bushii* | Bush's sedge | 1.75 | 40% |
| *Bouteloua curtipendula* | sideoats grama | 1.33 | 60% |
| *Panicum virgatum* | switchgrass | 1.33 | 60% |
| *Symphyotrichum pilosum* var. *pilosum* | hairy white oldfield aster | 1.33 | 60% |
| *Carex annectens* | yellowfruit sedge | 1.13 | 80% |
| *Erigeron annuus* | eastern daisy fleabane | 0.50 | 80% |
| *Potentilla recta* | sulphur cinquefoil | 0.50 | 80% |
| *Rudbeckia hirta* | blackeyed Susan | 0.50 | 80% |
| *Achillea millefolium* | common yarrow | 0.50 | 60% |
| *Conyza canadensis* | Canadian horseweed | 0.50 | 60% |
| *Desmodium paniculatum* | panicleleaf tickrefoil | 0.50 | 60% |
| *Elymus virginicus* | Virginia wildrye | 0.50 | 60% |
| *Galium virgatum* | limestone bedstraw | 0.50 | 60% |
| *Lactuca canadensis* | Canada lettuce | 0.50 | 60% |
| *Oxalis dillenii* | slender yellow woodsorrel | 0.50 | 60% |
| *Triodanis perfoliata* | clasping Venus' looking-glass | 0.50 | 60% |
| *Vulpia octoflora* | sixweeks fescue | 0.50 | 60% |
| *Apocynum cannabinum* | Indian hemp | 0.50 | 40% |
| *Carex scoparia* | broom sedge | 0.50 | 40% |
| *Cirsium altissimum* | tall thistle | 0.50 | 40% |
| *Dichanthelium acuminatum* var. *lindheimeri* | Lindheimer panicgrass | 0.50 | 40% |
| *Lespedeza capitata* | roundhead lespedeza | 0.50 | 40% |
| *Lespedeza cuneata* | sericea lespedeza | 0.50 | 40% |
| *Plantago virginica* | Virginia plantain | 0.50 | 40% |
| *Sphenopholis obtusata* | prairie wedgescale | 0.50 | 40% |
| *Symphyotrichum ericoides* var. *ericoides* | white heath aster | 0.50 | 40% |
| *Tragopogon dubius* | yellow salsify | 0.50 | 40% |

# Discussion

George Washington Carver National Monument currently has significant restored prairie and successional, but maturing woodlands and forests. Given that the surrounding landscape is used intensively for agricultural purposes, the vegetation of the park has real value for prairie and woodland wildlife species. Even though most of the park was at one time in row crop production, native grasses and forbs have been restored to a substantial area, and remnant mima mounds are still apparent on some of the landscape. This restored tallgrass prairie is probably the most significant plant community on the park.

**Field Survey**
The plant communities of GWCA will be quite dynamic over time because many are relatively early successional types. Documentation of change via repeated sampling will be highly desirable. Sampling of the general landscape around the park (e.g. interpretation of general vegetation types such as urban, grassland, and woodland/forest) will help to document context and provide early signs of urban encroachment on the boundaries, should that occur.

**NVC Classification**
Quantitative data from the park may help in the description of ruderal vegetation types for the Midwest. Currently, no ruderal type descriptions that correspond with the woodlands, forests, and shrublands exist. Some of these types are quite likely widespread on the landscape and provide the matrix habitats for native fauna and flora in the region (e.g. ruderal woodland and forest). Other ruderal types, such as the shrubland type, may actually be fairly uncommon or rare on the landscape, and valuable for native fauna. Forest, grassland, and especially shrubland birds of continental concern all nest within the park, which attests to the area's regional importance (Peitz 2009). Upland woodlands also provide shade and nutrient input for perennial streams that traverse the park, and harbor significant aquatic resources (Bowles 2009, Peitz 2005).

**Digital Imagery and Interpretation**
Multiple years of both leaf-on and leaf-off imagery were available for the park and were used to develop map polygons. The use of leaf-on and leaf-off data helped ensure high quality results. Because the park was small, heads up corrections to initial image objects were made at fine resolution. Small mapped polygons were retained in the final results, again due to the small size of the park.

**Accuracy Assessment**
The high degree of thematic accuracy was made possible in part by the small size of GWCA and the limited number of natural vegetation classes identified within the park. The overall accuracy assessment, as well as the accuracy assessment of each mapped class exceeded the 80% level required by the NPS Vegetation Mapping Inventory program. Further, the lower limit of the 90% confidence interval exceeded the programmatic requirement of 80% for each individual map class accuracy assessment.

**Future Recommendations**
The vegetation at GWCA consists mainly of early successional woodland and forest communities and restored prairie and thus will be quite dynamic over short time frames. For

example, woodlands and forest along Carver Creek, Williams Branch, and Harkin Creek may through succession become recognizable examples of a NCV Bottomland Forest type (e.g. *Fraxinus pennsylvanica – Celtis* spp.-*Quercus* spp.-*Platanus occidentalis* Bottomland Forest, CEGL002410). Monitoring of native flora and fauna by the Heartland Inventory and Monitoring Network will provide information on change. Efforts have already documented the status of the primary plant communities, species of concern, and invasive species (Annis et al. 2011, see also http:// science.nature.nps.gov/im/units/HTLN). The plant communities are quite simple and common in the landscape, yet these ruderal types are not described within the NVC. Data from this study should be made available to help facilitate possible NVC additions. Jones (2004) suggested that distinct wet prairie habitats may exist within the park, and areas circumscribed by him may warrant further monitoring. Likewise, woodlands and forests in the far northwestern section of the park have better drained soils than in other areas according to county soil surveys, and these areas may warrant further consideration and monitoring.

# Research Opportunities

Restoration of tallgrass prairie will be one of the most important on-going activities with regard to natural resources at GWCA. These activities may afford the opportunity for research on the effectiveness of various techniques (e.g. seeding, prescribed fire, mowing) on restoration efforts. Invasive Japanese honeysuckle (*Lonicera japonica*) and several additional non-native species are abundant in some of the ruderal woodlands and forests, and research on the effectiveness of various methods to control these species might be possible. Nesting birds and fish of regional and national significance are present in the park, and documentation of the impacts of management on those species may also be possible, especially if park staff decide to do away with the small, man-made lake in the central part of the park. Finally, a few mounds of mine tailings exist on the southwestern side of the park, and these are currently covered by ruderal woodland and forest, ruderal shrubland, or non-native ruderal grassland. The response of these areas, particularly of the mine tailing mounds themselves, may warrant future research.

# Literature Cited

Annis, G. M. DeBacker, D. Diamond, L. Elliott, A. Garringer, P. Hanberry, K. James, R. Lea, S. Leis, M. Morey, D. Pursell, and C. Young. 2011. George Washington Carver National Monument natural resource condition assessment. Natural Resource Report NPS/HTLN/NRR-2011/425.

Bowles, D.E. 2009. Aquatic invertebrate monitoring at George Washington Carver National Monument: 2005-2007. Natural Resource Technical Report NPS/HTLN/NRTR-2009/243. National Park Service, Fort Collins, Colorado.

Daubenmire, R.F. 1959. Canopy coverage method of vegetation analysis. Northwest Science 33:43-64

Federal Geographic Data Committee (FGDC). 1998. Spatial data transfer standard, FGDC-STD-002 (modified version ANSI NCITS 20:1998). Available at http://www.fgdc.gov/standards/.

Federal Geographic Data Committee. 2008. National vegetation classification standards. FGDC-STD-005-2008. Available at http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation/index_html.

Grossman D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I, The National Vegetation Classification System: development, status, and applications. The Nature Conservancy: Arlington, VA. Available at http://www.natureserve.org/publications/library.jsp#nspubs.

Harrington, J., S. Haswell, E. Howell, and A. Alanen. 1999. Springs of genius: an integrated management plan for George Washington Carver National Monument, Diamond, Missouri.

Jennings, M.D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet, and D. Roberts. 2009. Standards for Associations and alliances of the U.S. National Vegetation Classification. Ecological Monogrpahs 79:173-199.

Jones, B.A. 2004. Vascular plant inventory, George Washington Carver National Monument. Unpublished report. Heartland Inventory and Monitoring Network, National Park Service.

Lance, G. N. and W. T. Williams. 1966. A general theory of classificatory sorting strategies, I. Hierarchical Systems. Computer J. 9: 373-380.

Lea, C. 2011. Vegetation classification guidelines: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/NRPC/NRR-2011/374. National Parks Service, Fort Collins, Colorado.

Lea, C. and A. C. Curtis. 2010. Thematic accuracy assessment procedures: National Park Service Vegetation Inventory, version 2.0. Natural Resource Report NPS/2010/NRR—2010/204. National Park Service, Fort Collins, Colorado.

Legendre, P. and L. Legendre. 1998. Numerical Ecology. 2nd English Edition. Elsevier Science B. V., Amsterdam. 853 pp.

Maechler, M., P. Rousseeuw, A. Struyf, M. Hubert, and K. Hornik. 2011. cluster: Cluster Analysis Basics and Extensions. R package version 1.14.1. http://CRAN.R-project.org/package=cluster

National Park Service. 2011. 12-step guidance for NPS vegetation inventories. Available at http://science.nature.nps.gov/im/inventory/veg/docs/Veg_Inv_12step_Guidance_v1.1.pdf.

National Park Service. 2011a. NPS vegetation inventory program final product specifications. Guidelines for creating final products. Available at http://science.nature.nps.gov/im/inventory/veg/docs/Product_Specifications.pdf

NatureServe Explorer. 2012. An online encyclopedia of life. Ecological Communities & Systems. Available at http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol.

Peitz, D.G. 2005. Fish community monitoring in prairie park streams with emphasis on Topeka Shiner (*Notropis Topeka*): summary report 2001-2004. National Park Service, Heartland I&M Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield, Republic, Missouri.

Peitz, D.G. 2009. Bird monitoring at George Washington Carver National Monument, Missouri. 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR-2009/193. National Park Service, Fort Collins, Colorado.

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

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

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

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

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

# Appendix A: Contingency Table for Vegetation Mapping at George Washington Carver National Monument

| | Reference Data (Accuracy Assessment Field Data) | | | | | | User's Error | | |
|---|---|---|---|---|---|---|---|---|---|
| | Map Units | Ruderal woodland and forest | Ruderal shrubland | Non-native ruderal grassland | Restored tallgrass prairie | Totals | Commission Accuracy | 90% Conf. Interval | |
| | | | | | | | | - | + |
| Sample Data (Polygon Map Data) | Ruderal woodland and forest | **3** | 0 | 0 | 0 | 3 | 100% | 83.3% | 100% |
| | Ruderal shrubland | 0 | **4** | 0 | 0 | 4 | 100% | 87.5% | 100% |
| | Non-native ruderal grassland | 0 | 0 | **5** | 0 | 5 | 100% | 90.0% | 100% |
| | Restored tallgrass prairie | 0 | 0 | 0 | **4** | 4 | 100% | 87.5% | 100% |
| | Totals | 3 | 4 | 5 | 4 | | | | |
| Producer's Error | Omission Accuracy | 100% | 100% | 100% | 100% | **16 Total Correct Points** | | | |
| | 90% Conf. - | 100% | 100% | 100% | 100% | **16 Total Points** | | | |
| | Level + | 100% | 100% | 100% | 100% | | | | |

**Overall Total Accuracy = 100%    Overall Kappa Index = 100%    Overall 90% Upper and Lower Confidence Interval = 100% and 100%**

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

# Appendix B: Example of Plot Survey Form

**NPS VEGETATION MAPPING PROGRAM – PLOT SURVEY FORM**
**PLOT LOCATION AND DESCRIPTION**

Plot Code ________________ Surveyors ________________
Date________________

Plot Directions

______________________________________________________________

Plot Dimensions ______ by ______m Photos (y/n) ___________
Provisional Community Name

______________________________________________________________

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

______________________________________________________________
______________________________________________________________
______________________________________________________________

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

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

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

Plot Shape (circle) concave convex flat irregular
General Comments

______________________________________________________________
______________________________________________________________
______________________________________________________________

Plot Code ____________

**NPS VEGETATION MAPPING PROGRAM – PLOT SURVEY FORM**

**VEGETATION SAMPLING**

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

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

**SPECIES COMPOSITION AND COVER CLASS BY STRATUM**

%Cover (1=<1%, 2=1-5%, 3=5-25%, 4=25-50%, 5=50-75%, 6=75-95%, 7=95-100%)

| T1 | T2 | T3 | S1 | S2 | H | Species | Comments |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Plot Code ___________

| T1 | T2 | T3 | S1 | S2 | H | Species | Comments |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# Appendix C: George Washington Carver National Monument Dichotomous Key to Mapped Current Vegetation Types

1a. Vegetation dominated by herbaceous species with absolute cover of woody species <30% except in patches <500 square meters (small patches of shrublands may be included here) …………….. 2

2a. Native tallgrass prairie species such as big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and composite dropseed (*Sporobolus compositus* var. *compositus*) among the dominants……………………………………………….Restored Tallgrass Prairie

2b. Native tallgrass prairie species not among the dominants. Non-native and ruderal grasses such as tall fescue (*Schedonorus phoenix*) among the dominants ………………….. ……………………………………………………………….Non-native Ruderal Grassland

1b. Vegetation dominated by woody species with absolute cover of all trees and shrubs combined greater than 30% except in patches <500 square meters ……………………………………….……..3

3a. Vegetation dominated by trees >5 m tall with total absolute woody canopy cover greater than 70%. Species such as black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), and slippery elm (*Ulmus rubra*) important in the canopy and/or sub-canopy ..........................................................................................Ruderal Woodland and Forest

3b. Vegetation dominated by shrubs or small trees with absolute total woody canopy less than 70%. Species such as Osage orange (*Maclura pomifera*) and honey locust (*Gleditsia triacanthos*) among the woody dominants and non-native or annual grasses such as tall fescue (*Schedonorus phoenix*) among the herbaceous dominants…………………………………………………………...Ruderal Shrubland

# Appendix D: Example of Accuracy Assessment Form

**Accuracy Assessment Form**

**NPS Vegetation Inventory**

**1. PLOT (WAYPOINT) #:____________________ 2. DATE:______________**

**3. OBSERVER (DETERMING ASSOCIATION) ______________________________**

**4. Observer (assisting) ___________________________________________________**

**5. ACCURACY OF NAVIGATION (METERS) _______________________________**

**6. How Determined: _____________________________________________________**

**7. UTM EASTING: _____________________ 8. UTM: ____________________**

**9. UTM Zone: _______________________ 10. Datum: __________________**

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

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

**b.) Physical constraints in reaching waypoint**

**c.) Other (explain as needed):___________________________________________________**

**__________________________________________________________________________**

**__________________________________________________________________________**

**12. VEGETATION ASSOCIATION (Primary call): ______________________________**

**__________________________________________________________________________**

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

**__________________________________________________________________________**

**14. Explanation for # 13 (if applicable): __________________________________________**

**__________________________________________________________________________**

# Appendix E: Species List for George Washington Carver National Monument

| Family | Scientific Name | Common Name |
|---|---|---|
| **Acanthaceae** | *Ruellia strepens* | limestone wild petunia |
| **Aceraceae** | *Acer negundo* | boxelder |
| **Anacardiaceae** | *Rhus copallinum* | winged sumac |
| | *Rhus glabra* | smooth sumac |
| | *Toxicodendron radicans* | eastern poison ivy |
| **Apiaceae** | *Cryptotaenia canadensis* | Canadian honewort |
| | *Osmorhiza claytonii* | Clayton's sweetroot |
| | *Sanicula canadensis* | Canadian blacksnakeroot |
| | *Sanicula odorata* | clustered blacksnakeroot |
| | *Torilis arvensis* | spreading hedgeparsley |
| **Apocynaceae** | *Apocynum cannabinum* | Indianhemp |
| **Araceae** | *Arisaema dracontium* | green dragon |
| **Aspleniaceae** | *Asplenium platyneuron* | ebony spleenwort |
| **Asteraceae** | *Achillea millefolium* | common yarrow |
| | *Ageratina altissima* var. *altissima* | white snakeroot |
| | *Ambrosia artemisiifolia* | annual ragweed |
| | *Ambrosia trifida* | great ragweed |
| | *Cirsium altissimum* | tall thistle |
| | *Conyza canadensis* | Canadian horseweed |
| | *Elephantopus carolinianus* | Carolina elephantsfoot |
| | *Erechtites hieraciifolia* | American burnweed |
| | *Erigeron annuus* | eastern daisy fleabane |
| | *Erigeron strigosus* | prairie fleabane |
| | *Gamochaeta purpurea* | spoonleaf purple everlasting |
| | *Hieracium gronovii* | queendevil |
| | *Krigia biflora* | twoflower dwarfdandelion |
| | *Lactuca canadensis* | Canada lettuce |
| | *Lactuca floridana* | woodland lettuce |
| | *Prenanthes altissima* | tall rattlesnakeroot |
| | *Rudbeckia hirta* | blackeyed Susan |
| | *Silphium perfoliatum* | cup plant |
| | *Solidago altissima* | Canada goldenrod |
| | *Solidago gigantea* | giant goldenrod |
| | *Symphyotrichum ericoides* var. *ericoides* | white heath aster |
| | *Symphyotrichum oolentangiense* var. *oolentangiense* | skyblue aster |
| | *Symphyotrichum patens* var. *patens* | late purple aster |

# Appendix E: Species List for George Washington Carver National Monument

| Family | Scientific Name | Common Name |
|---|---|---|
| **Asteraceae** | *Symphyotrichum pilosum* var. *pilosum* | hairy white oldfield aster |
| | *Symphyotrichum turbinellum* | smooth violet prairie aster |
| | *Tragopogon dubius* | yellow salsify |
| | *Verbesina alternifolia* | wingstem |
| | *Verbesina virginica* | white crownbeard |
| | *Vernonia arkansana* | Arkansas ironweed |
| | *Vernonia baldwinii* | Baldwin's ironweed |
| **Balsaminaceae** | *Impatiens* | touch-me-not |
| **Boraginaceae** | *Hackelia virginiana* | beggarslice |
| **Campanulaceae** | *Triodanis perfoliata* | clasping Venus' looking-glass |
| **Caprifoliaceae** | *Lonicera flava* | yellow honeysuckle |
| | *Lonicera japonica* | Japanese honeysuckle |
| | *Sambucus nigra* ssp. *canadensis* | American black elderberry |
| | *Symphoricarpos orbiculatus* | coralberry |
| | *Viburnum rufidulum* | rusty blackhaw |
| | *Dianthus armeria* | Deptford pink |
| **Caryophyllaceae** | *Silene stellata* | widowsfrill |
| **Celastraceae** | *Euonymus fortunei* | winter creeper |
| **Cupressaceae** | *Juniperus virginiana* | eastern redcedar |
| **Cyperaceae** | *Carex amphibola* | eastern narrowleaf sedge |
| | *Carex annectens* | yellowfruit sedge |
| | *Carex blanda* | eastern woodland sedge |
| | *Carex bushii* | Bush's sedge |
| | *Carex jamesii* | James' sedge |
| | *Carex nigromarginata* | black edge sedge |
| | *Carex retroflexa* | reflexed sedge |
| | *Carex scoparia* | broom sedge |
| **Dryopteridaceae** | *Woodsia obtusa* | bluntlobe cliff fern |
| **Euphorbiaceae** | *Acalypha virginica* | Virginia threeseed mercury |
| | *Croton monanthogynus* | prairie tea |
| | *Tragia betonicifolia* | betonyleaf noseburn |
| **Fabaceae** | *Amorpha canescens* | leadplant |
| | *Cercis canadensis* | eastern redbud |
| | *Desmodium marilandicum* | smooth small-leaf ticktrefoil |
| | *Desmodium paniculatum* | panicledleaf ticktrefoil |
| | *Desmodium perplexum* | perplexed ticktrefoil |

# Appendix E: Species List for George Washington Carver National Monument

| Family | Scientific Name | Common Name |
|---|---|---|
| **Fabaceae** | *Gleditsia triacanthos* | honeylocust |
| | *Lespedeza capitata* | roundhead lespedeza |
| | *Lespedeza cuneata* | sericea lespedeza |
| | *Lespedeza violacea* | violet lespedeza |
| | *Robinia pseudoacacia* | black locust |
| | *Strophostyles helvola* | amberique-bean |
| | *Trifolium campestre* | field clover |
| | *Trifolium pratense* | red clover |
| | *Vicia sativa* | garden vetch |
| **Fagacaea** | *Quercus alba* | white oak |
| | *Quercus macrocarpa* | bur oak |
| | *Quercus muehlenbergii* | chinkapin oak |
| | *Quercus velutina* | black oak |
| **Grossulariaceae** | *Ribes missouriense* | Missouri gooseberry |
| **Juglandaceae** | *Juglans nigra* | black walnut |
| **Juncaceae** | *Juncus tenuis* | poverty rush |
| **Lamiaceae** | *Glechoma hederacea* | ground ivy |
| | *Physostegia virginiana* | obedient plant |
| | *Prunella vulgaris* | common selfheal |
| | *Scutellaria incana* | hoary skullcap |
| | *Teucrium canadense* | Canada germander |
| | *Allium vineale* | wild garlic |
| **Liliaceae** | *Trillium sessile* | toadshade |
| **Moraceae** | *Maclura pomifera* | Osage orange |
| | *Morus rubra* | red mulberry |
| **Oleaceae** | *Fraxinus americana* | white ash |
| | *Fraxinus pennsylvanica* | green ash |
| | *Ligustrum vulgare* | European privet |
| **Ophioglossaceae** | *Botrychium virginianum* | rattlesnake fern |
| **Oxalidaceae** | *Oxalis dillenii* | slender yellow woodsorrel |
| | *Oxalis stricta* | common yellow oxalis |
| **Passifloraceae** | *Passiflora lutea* | yellow passionflower |
| **Phytolaccaceae** | *Phytolacca americana* | American pokeweed |
| **Plantaginaceae** | *Plantago virginica* | Virginia plantain |
| **Platanaceae** | *Platanus occidentalis* | American sycamore |

# Appendix E: Species List for George Washington Carver National Monument

| Family | Scientific Name | Common Name |
|---|---|---|
| **Poaceae** | *Agrostis hyemalis* | winter bentgrass |
| | *Andropogon gerardii* | big bluestem |
| | *Andropogon virginicus* | broomsedge bluestem |
| | *Bouteloua curtipendula* | sideoats grama |
| | *Bromus arvensis* | field brome |
| | *Bromus pubescens* | hairy woodland brome |
| | *Bromus tectorum* | cheatgrass |
| | *Chasmanthium latifolium* | Indian woodoats |
| | *Dactylis glomerata* | orchardgrass |
| | *Dichanthelium acuminatum* var. *fasciculatum* | western panicgrass |
| | *Dichanthelium acuminatum* var. *lindheimeri* | Lindheimer panicgrass |
| | *Dichanthelium clandestinum* | deertongue |
| | *Dichanthelium commutatum* | variable panicgrass |
| | *Dichanthelium malacophyllum* | softleaf rosette grass |
| | *Elymus virginicus* | Virginia wildrye |
| | *Festuca subverticillata* | nodding fescue |
| | *Leersia virginica* | whitegrass |
| | *Muhlenbergia sobolifera* | rock muhly |
| | *Panicum virgatum* | switchgrass |
| | *Poa annua* | annual bluegrass |
| | *Poa chapmaniana* | Chapman's bluegrass |
| | *Poa compressa* | Canada bluegrass |
| | *Poa sylvestris* | woodland bluegrass |
| | *Schedonorus phoenix* | tall fescue |
| | *Schedonorus pratensis* | meadow fescue |
| | *Schizachyrium scoparium* | little bluestem |
| | *Sorghastrum nutans* | Indiangrass |
| | *Sphenopholis obtusata* | prairie wedgescale |
| | *Sporobolus compositus* var. *compositus* | composite dropseed |
| | *Tridens flavus* | purpletop tridens |
| | *Vulpia octoflora* | sixweeks fescue |
| | *Vulpia octoflora* var. *octoflora* | sixweeks fescue |
| **Polygonaceae** | *Polygonum sp.* | knotweed species |
| | *Polygonum virginianum* | jumpseed |

# Appendix E: Species List for George Washington Carver National Monument

| Family | Scientific Name | Common Name |
|---|---|---|
| **Rosaceae** | *Geum canadense* | white avens |
| | *Geum vernum* | spring avens |
| | *Potentilla recta* | sulphur cinquefoil |
| | *Prunus americana* | American plum |
| | *Prunus hortulana* | hortulan plum |
| | *Prunus serotina* | black cherry |
| | *Rosa multiflora* | multiflora rose |
| | *Rubus pensilvanicus* | Pennsylvania blackberry |
| **Rubiaceae** | *Galium aparine* | stickywilly |
| | *Galium virgatum* | southwestern bedstraw |
| **Sapotaceae** | *Sideroxylon lanuginosum* | gum bully |
| **Scrophulariaceae** | *Agalinis tenuifolia* | slenderleaf false foxglove |
| | *Verbascum blattaria* | moth mullein |
| **Smilacaceae** | *Smilax bona-nox* | saw greenbrier |
| | *Smilax tamnoides* | bristly greenbrier |
| **Solanaceae** | *Solanum carolinense* | Carolina horsenettle |
| **Ulmaceae** | *Celtis laevigata* | sugarberry |
| | *Celtis occidentalis* | common hackberry |
| | *Ulmus alata* | winged elm |
| | *Ulmus americana* | American elm |
| | *Ulmus rubra* | slippery elm |
| **Urticaceae** | *Pilea pumila* | Canadian clearweed |
| **Valerianaceae** | *Valerianella radiata* | beaked cornsalad |
| **Verbenaceae** | *Phryma leptostachya* | American lopseed |
| **Violaceae** | *Viola pubescens* var. *pubescens* | downy yellow violet |
| | *Viola sagittata* | arrowleaf violet |
| | *Viola sororia* | common blue violet |
| **Vitaceae** | *Parthenocissus quinquefolia* | Virginia creeper |
| | *Vitis aestivalis* | summer grape |
| | *Vitis vulpina* | frost grape |

NPS 397/120409, April 2013

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

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

www.nature.nps.gov