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Southern Plains Inventory and Monitoring Network
Johnson City, Texas

Vegetation Classification and Mapping Project Report, Washita Battlefield National Historic Site

Natural Resource Technical Report NPS/SOPN/NRTR—2007/075

ON THE COVER
Sunrise at Washita National Battlefield
Photograph by: NPS

Vegetation Classification and Mapping Project Report, Washita Battlefield National Historic Site

Natural Resource Technical Report NPS/SOPN/NRTR—2007/075

A Report for the Southern Plains Inventory and Monitoring Network

National Park Service
Southern Plains Inventory and Monitoring Network
P.O. Box 329 (mailing)
100 Ladybird Lane (physical)
Johnson City, TX 78636

Author
Dan Cogan
Cogan Technology Inc.
21 Valley Road Galena, IL 61036

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List of Contacts and Contributors

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

Karl Brown Ph. D.
Vegetation Mapping Program Manager
1201 Oakridge Drive, Suite 200
Fort Collins, CO 80525
Phone: 970-225-3591
Email: karl_brown@nps.gov

Dusty Perkins Ph. D.
S. Plains Network Coordinator
P.O. Box 329, 100 Ladybird Lane
Johnson City, TX 78636
Phone: 830-868-7128 ext. 281
Email: dustin_w_perkins@nps.gov

Wendy Lauritzen
WABA Superintendent
PO Box 890
Cheyenne, OK 73628
Phone: 580 497-2742 x1
Email: wendy_lauritzen@nps.gov

NatureServe

Jim Drake
Regional Vegetation Ecologist
1101 West River Parkway Suite 200
Minneapolis, Minnesota 55415
Phone: 612-331-0729
E-mail: jim_drake@natureserve.org

Cogan Technology, Inc.

Dan Cogan
Environmental Scientist and GIS Specialist
21 Valley Road
Galena, IL 61036
Phone: 815-777-1773
E-mail: dancogan@cogantech.com

U. S. Department of the Interior - United States Geological Survey – Biological Resources Division

Mike Mulligan
USGS Program Coordinator
USGS-Center for Biological Informatics (CBI)
Phone: 303-202-4242
E-mail: mike_mulligan@usgs.gov

Theresa Singh
Website and Data Manager
USGS-Center for Biological Informatics
Phone: 303-202-4227
E-mail: theresa_singh@usgs.gov

U. S. Department of the Interior - Bureau of Reclamation

Michael Pucherelli
Group Manager GIS / Remote Sensing Group
P.O. Box 25007 Mail Stop 86-68260
Denver Federal Center - Bldg. 56
Denver, CO 80225
Phone: 303-445-2267
E-mail: mpucherelli@do.usbr.gov

David E. Salas
Physical Scientist
Phone 303-445-3619
Fax: 303-445-6337
E-mail: desalas@do.usbr.gov

Others: Heidi Sosinski & **Tomye Folts-Zettner** - Southern Plains Network, **Roger Sanders** - formerly with Biological Research Institute of Texas, **Chris Lea** - NPS Botanist Vegetation Mapping Program, **Dick Zahm** WABA Park Guide, **Alden Miller** Former WABA Chief of Resources and Facilities.

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Special recognition goes to Karl Brown, Mike Story and Chris Lea with NPS for making this project happen and being there for help with coordination, logistics, and financial matters.

I would like to extend a real big thank you to Roger Sanders for providing an extremely rich data-set of invaluable plot, accuracy assessment and photo verification data.

Finally, let me apologize to anyone I may have overlooked. Please know that I had a great experience working and meeting with everyone associated with this endeavor and I really appreciate all the effort that went into this project. - Dan.

List of Abbreviation and Acronyms

AA	Accuracy Assessment
AML	Arc Macro Language
BOR	Bureau of Reclamation (also USBR)
BRD	Biological Resource Division (of the USGS)
BRIT	Botanical Research Institute of Texas
CBI	Center for Biological Informatics (of the USGS/BRD)
CTI	Cogan Technology Inc.
FGDC	Federal Geographic Data Committee
FSA	Farm Service Agency
GIS	Geographic Information System(s)
GPS	Global Positioning System
MMU	Minimum Mapping Unit
NAD	North American Datum
NAIP	National Agriculture Imagery Program
NBII	National Biological Information Infrastructure
NPS	U.S. National Park Service
NRCS	Natural Resources Conservation Service
NVC	National Vegetation Classification
NVCS	National Vegetation Classification System
RSGIG	Remote Sensing and Geographic Information Group
SOPN	Southern Plains Inventory and Monitoring Network
TNC	The Nature Conservancy
USBR	United States Bureau of Reclamation (also BOR)
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WABA	Washita Battlefield National Historic Site

Links

http://www.nature.nps.gov/im/units/sopn/index.cfm	Southern Plains Inventory and Monitoring Network
http://biology.usgs.gov/npsveg/index.html	USGS-NPS Vegetation Mapping Program
http://www.nps.gov	The National Park Service
http://usgs.gov	United States Geologic Survey
http://biology.usgs.gov/cbi	USGS Center for Biological Informatics
http://biology.usgs.gov/cbi/nbii	National Biological Information Infrastructure
http://www.nps.gov/waba	Washita Battlefield National Historic Site
http://www.usbr.gov	United States Bureau of Reclamation
http://www.natureserve.org	NatureServe
http://www.natureserve.org/explorer	NatureServe Explorer® online database server
http://plants.usda.gov	NRCS PLANTS Database

Executive Summary

Washita Battlefield National Historic Park (WABA) encompasses approximately 315 acres in the Osage and High Plains section of western Oklahoma, approximately 2 miles west of Cheyenne, OK and 20 miles east of the Texas border (halfway between Amarillo, Texas and Oklahoma City, Oklahoma). This unique site preserves the location of a tragic battle between the Southern Cheyenne Tribe and the U.S. Calvary occurring in 1868. WABA is rectangular in shape and the visitor overlook is situated on rolling uplands containing a few red mounds of earth characteristic of this part of Oklahoma. From the trailhead, the park gently slopes down to the Washita River, crossing large floodplain bottomlands and old river channels. The vegetation at this site is in flux due to past agricultural and cultural activities such as clearing for farming, grazing, a railroad right-of-way and past homestead sites. Although non-native plants are present, the park is actively controlling them through removal and native prairie restoration. Intermixed with these types are stable, remnant native plant populations occurring in the riparian corridors and on the rocky hilltops. To better understand the distribution of these plant assemblages the NPS Southern Plains Inventory and Monitoring Network (SOPN) started a vegetation mapping and classification effort at WABA in 2005.

A three-year program was initiated to complete the task of mapping and classifying the vegetation at WABA. Phase one, directed by the Botanical Research Institute of Texas (BRIT) in conjunction with NatureServe developed a vegetation classification using the National Vegetation Classification System (NVCS). Phase two, directed by the U.S. Bureau of Reclamation's (BOR) Remote Sensing and Geographic Information Group in conjunction with Cogan Technology, Inc (CTI) produced a digital vegetation map. To classify the vegetation, 31 representative plots located throughout the approximately 924 acre project area (park + environs) were sampled during the summer of 2005. Analysis of the plot data by NatureServe in the winter of 2005-2006 produced 11 distinct plant associations and alliances. One of which was newly described in the National Vegetation Classification (NVC). In addition, CTI described 4 more alliances, 1 more association and 4 distinctive stands of vegetation (i.e. Park Specials) that primarily occurred as small stands in the park or were located outside of the park in the environs. Descriptions and a field key for all 20 unique plant assemblages for WABA are included in this report.

To produce the digital map, a combination of 1:12,000-scale true color digital ortho-imagery acquired in 2003, 1:12,000-scale true color ortho-rectified imagery acquired in 2005, and all of the GPS referenced ground data were used to interpret the complex patterns of vegetation and land-use. All imagery was acquired from the U.S. Department of Agriculture - Farm Service Agency's Aerial Photography Field Office and the National Agriculture Imagery Program. In the end, 27 map units were developed and directly cross-walked or matched to corresponding plant associations/alliances and land-use classes. All of the interpreted and remotely sensed data were converted to Geographic Information System (GIS) databases using ArcGIS© software. Draft maps were printed, field tested, reviewed and revised. One hundred and five accuracy assessment (AA) data points were collected in 2006 and used to determine the map's accuracy. After final revisions, the accuracy assessment revealed an overall thematic accuracy of 88%.

Products developed for Washita Battlefield National Historic Site are described and presented in this report, and are stored on the accompanying DVD. These include:

- A *Final Report* that includes keys to the vegetation and imagery signatures, AA information, and all of the methods and results of the project;
- A *Spatial GIS Database* containing spatial data for the vegetation, plots, AA points and observation points;
- *Digital Photos* from sample plots and miscellaneous park views;
- *Metadata* for all spatial data [Federal Geographic Data Committee (FGDC)-compliant];
- *Vegetation Descriptions and Photo Signature Key* to the map classes and associations/alliances.

In addition, WABA and the SOPN both received copies of:
- Digital data files and hard copy data sheets of the observation points, vegetation field plots, and accuracy assessment points;
- Hardcopy vegetation maps.

Additional data not included in this report can be found on the attached DVD. This includes text and metadata files, keys, lists, field data, spatial data, the vegetation map, and ground photos. Please check the following USGS website for posting of this information: http://biology.usgs.gov/npsveg/index.html

For more information on the NVCS and NVC alliances/associations in the United States please go to NatureServe's website: http://www.natureserve.org.

The Washita River at WABA.
Photograph by: Roger Sanders

Project Statistics

Field Work Summers of 2005 and 2006:

Plot Sampling = 31
31 Plots Sampled in September by Roger Sanders and staff from the Botanical Research Institute of Texas and Tomye Folts Zettner from Southern Plains Inventory and Monitoring Network.

Accuracy Assessment Points = 105
105 Points collected in 2006 by Roger Sanders from the Botanical Research Institute of Texas and Tomye Folts-Zettner from the Southern Plains Network.

Observation and Incidental Points = 62
50 Observation Points and 12 Incidental Points collected in 2006 by Jim Von Loh of Engineering-Environmental Management, Inc.

Classification:

14 NVC Plant Associations and Alliances

GIS Database 2002-2005:

Project Size = 924 acres
Washita Battlefield National Historic Site = 320 acres

Base Imagery acquired from the USDA FSA Aerial Photography Field Office acquired through the National Agriculture Imagery Program:
2005 - 1:12,000-scale true color ortho-rectified imagery, compressed county mosaic, 2 meter pixel resolution
2003 - 1:12,000-scale color infrared digital ortho-imagery, compressed county mosaic, 1 meter pixel resolution

Map Classes = 27
20 = Vegetated
7 = Non-vegetated

Minimum Mapping Unit = ½ hectare is the program standard but this was modified at WABA to ¼ acre.

Total Size = 383 Polygons

Average Polygon Size = 2.4 acres

Overall Thematic Accuracy = 88%

Project Completion Date: 05/31/07

Introduction

Background

In 1994, the U.S. Geological Survey (USGS) and NPS formed the USGS-NPS Vegetation Mapping Program to cooperatively inventory and map the vegetation in the United States National Parks. The goals of this program are to provide baseline ecological data for park resource managers, obtain data that can be examined in a regional and national context, and provide opportunities for future inventory, monitoring, and research activities (FGDC 1997, Grossman et al. 1998).

In the same year, the USGS-NPS Vegetation Mapping Program also adopted the U.S. National Vegetation Classification (USNVC) (The Nature Conservancy and Environmental Systems Research Institute 1994a, Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The Federal Geographic Data Committee adopted a modified version of the upper (physiognomic) levels as a federal standard (FGDC-STD-005) (FGDC 1997). This standard was hereafter termed the National Vegetation Classification Standard (NVCS). The NVCS established a federal standard for a complete taxonomic treatment of vegetation in the United States at physiognomic levels. It also established conceptual taxonomic levels for the floristic units of alliance and association, largely following the USNVC, but did not offer a taxonomic treatment for the floristic levels because of the immense scope of establishing robust floristic units for the entire United States. The FGDC standard requires that federally funded vegetation classification efforts collect data in a manner that enables crosswalking the data to the NVCS (i.e., the physiognomic levels) and sharing between agencies, but does not require use of that standard by agencies for internal mission needs. NatureServe maintains a treatment of floristic units (alliances and associations), which, though not a federal standard, are used as classification and mapping units by the vegetation mapping program whenever feasible. For purposes of this document, the federal standard (FGDC 1997) is denoted as the NVCS; the USNVC will refer exclusively to NatureServe's treatment for vegetation floristic units (alliances and associations only).

Use of the NVCS as the standard vegetation classification system 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;
- is appropriate for mapping at multiple scales.

The use of the NVCS and the USGS-NPS vegetation mapping protocols facilitate 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.

The NVC has primarily been developed and implemented by The Nature Conservancy (TNC) and the network of State Natural Heritage Programs over the past twenty years (TNC 1994a; Grossman et al. 1998). The NVC is currently supported and endorsed by multiple federal agencies, the FGDC, NatureServe, State Heritage Programs, and the Ecological Society of America. Refinements to the classification occur in the process of application, leading to ongoing proposed revisions that are reviewed both locally and nationally. TNC and NatureServe have made available a 2-volume publication presenting the standardized classification, providing a thorough introduction to the classification, its structure, and the list of vegetation types found across the United States as of April 1997 (Grossman et al. 1998). *Volume I: The National Vegetation Classification Standard* can be found on the Internet at: http://www.natureserve.org/publications/library.jsp.

NatureServe has since superseded Volume II of the publication (the classification listing), providing regular updates to ecological communities in the United States and Canada. This online database server, NatureServe Explorer®, can also be found on the Internet at: http://www.natureserve.org/explorer.

Washita Battlefield National Historic Site

WABA was established on November 12th, 1996 to recognize an important and tragic conflict during the western expansion of the United States. Situated on the floodplain of the Washita River, it was here on November 27, 1868 that the 7th U.S. Calvary attacked the winter camp of the Southern Cheyenne Tribe led by Peace Chief Black Kettle. Conflict started before dawn on the 27th as Lt. Col. George A. Custer and his roughly 800 troops struck the 51 lodges on this bend in the Washita River. During the raid Custer claimed about 100 native casualties (including many women and children) but contrasting accounts by the Cheyenne reported much lower fatalities at 11 warriors and 19 women and children. Among the victims were Chief Black Kettle and his wife. Lt. Col. Custer also captured more than 50 Cheyenne, mainly women and children. His troops only experienced light losses, including 2 officers and 19 enlisted men. After the battle, Lt. Col. Custer ordered the slaughter of the Indian pony and mule herd estimated at more than 800 animals and the torching of all the lodges including their winter supply of food.

WABA is located in a rural section of Oklahoma just west of the town of Cheyenne in Roger Mills County. The Visitor Center and Park Headquarters are currently located in Cheyenne, however a new cultural center and visitor contact station is being constructed on-site with the opening scheduled during April 2007. All of the land surrounding WABA is private, however 31,300 acres of public land in the Black Kettle National Grassland (administered by the Cibola National Forest) occurs nearby.

Natural Setting

WABA is located in the Osage and High Plains section of Western Oklahoma. This area is historically characterized as having vast tracts of tall and midgrass prairie interspersed with stands of oak and juniper. Wetlands are common in the area including ponds, lakes and streams supporting cottonwood and other deciduous trees and shrubs. Due to its location, this area is transitional and has historically supported plant species common to both the western and eastern portions of the United States. The climate at Cheyenne is subtropical with warm, humid summers and short mild winters. The average elevation is 1,965 feet and the park contains flat, bottomland areas and rolling uplands with a few red hills. The characteristic red hills were created by eroding of the Permian red-bed sandstones, siltstones, mudstones and gypsum that underlies most of this region of Oklahoma (Branson & Johnson 1979). The bottomlands are characterized by three alluvial terraces that contain layers of deposited sand, silt, and clay. The primary soil associations are the Yahola-Port composed of alluvial soils and the very steep loamy soils on the red sandstone belonging to the Woodward-Quinlan association (Burgess et al. 1959).

The land has sustained many uses since the time of the Southern Cheyenne Tribe including farming and ranching. Almost all of the gentle sloping to flat floodplain lands at WABA were cleared at one time to create fields supporting crops and pasture. Also WABA once contained a homestead, trash pit and a railroad that bisected the park from east to west. Much of the land development on the park has been removed but some evidence of the past uses is still evident such as the grading for the railroad. This area of Oklahoma has experienced much oil and gas development as it overlies the Anardarko Basin. Oil production was once a vital part of this area's economy and oil rigs and wells can still be found in the vicinity. Farming and other land-use activities over the years have had profound effects on the vegetation including the on-going

presence of many non-native species that were likely planted or introduced to the area. WABA is conducting on-going restoration efforts including the planting and maintaining (i.e. burning) of native prairie and is actively removing non-native trees such as Siberian elms in the desire to return the landscape to a more pristine setting.

Vegetation

The vegetation at WABA contains a mix of native plants common to the western portion of Oklahoma and introduced non-native species. Past inventory efforts recorded 361 species of vascular plants at WABA including species from 258 genera and 86 families (Hoagland et al 2005). Of these species 106 are annuals and 241 are perennials. This study also recorded 60 woody plant species, 39 exotics (comprising 9.1% of the total flora at WABA) and included 5 species of concern tracked by the Oklahoma Natural Heritage Inventory.

WABA has been described as supporting 3 general habitat types comprising the riparian, sand dunes/hills, and disturbed old field vegetation (Hoagland et al 2005). The riparian area is located along the channels of the Washita River and its tributaries. Eastern cottonwood (*Populus deltoides*) and western soapberry (*Sapindus saponaria*) are the dominant trees although Siberian elm (*Ulmus pumila*) and gumbully (*Sideroxylon lanuginosum*) are also common. Riparian shrubs include Chickasaw plum (*Prunus angustifolia*), black willow (*Salix nigra*), false indigo (*Amorpha fruticosa*) and smooth sumac (*Rhus glabra*). Herbaceous species of the riparian habitat are usually lush wetland species including threesquare (*Schoenoplectus pungens*). The upland sand hills contain many species that are endemic to sandy soils. These include sand sagebrush (*Artemisia filifolia*) and yucca (*Yucca glauca*) in the shrub stratum and sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium*) and blue grama (*Bouteloua gracilis*) in the herbaceous layer. In addition, stands of Siberian elm and soapberry can also be found on more mesic areas such as north-facing slopes. The old field areas are widespread and contain a mix of introduced grasses, annual forbs and restoration plantings of native species. Common species in this habitat include sumpweed (*Iva annua*), giant ragweed (*Ambrosia trifida*), yellow sweetclover (*Melilotus officinalis*), maple-leaved goosefoot (*Chenopodium simplex*), Indiangrass (*Sorghastrum nutans*), Bermuda grass (*Cynodon dactylon*), Johnsongrass (*Sorghum halepense*), and cheatgrass (*Bromus tectorum*).

WABA Vegetation Mapping Project

The specific decision to classify and map the vegetation at WABA was made in response to guidelines set forth by the NPS Natural Resources Inventory and Monitoring Program and implemented by the SOPN. The SOPN consists of 11 National Park units spread across 5 states in the south central portion of the United States (Figure 1). This network of parks was formed to create and centralize much-needed information about the nature and status of selected biological resources occurring within park boundaries so as to be used for making management decisions, for scientific research, and for educating the public. One of the goals of this network is to provide baseline inventory information for resource management and to help monitor the health of park ecosystems. Stemming from this goal, developing a vegetation classification to the plant community level and associated GIS map and database for each park was viewed as a high priority.

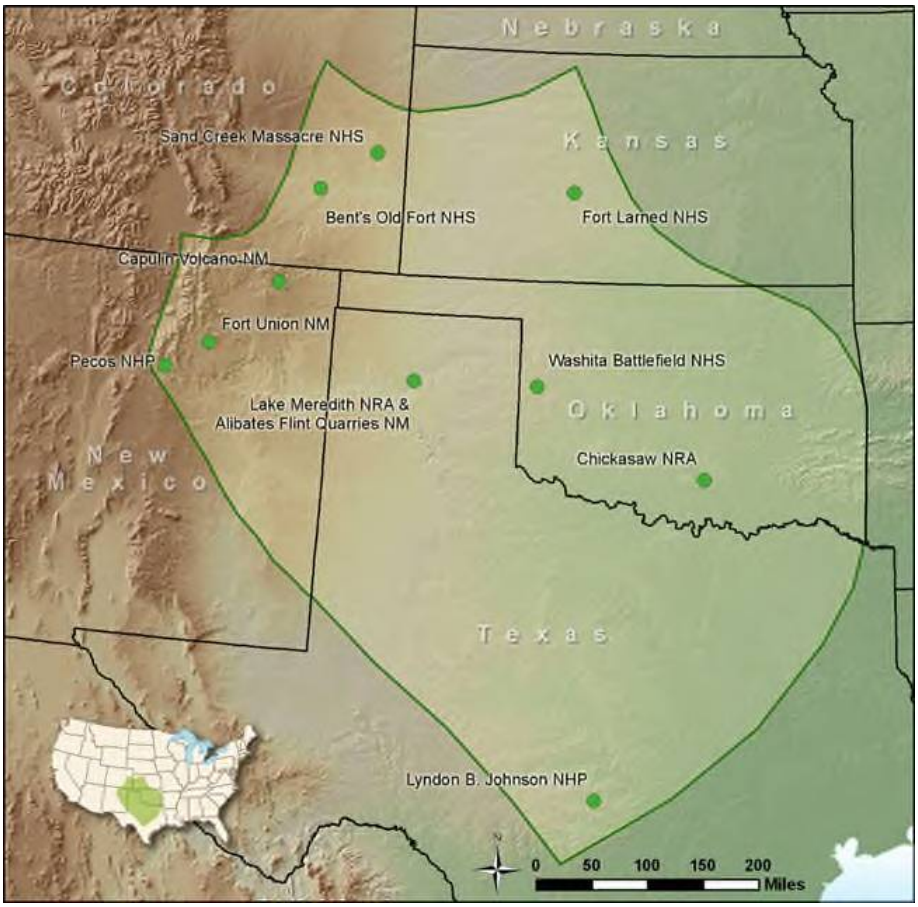

Figure 1. Map of SOPN showing the location of the park units in the network.

In 2005 Dusty Perkins, the network coordinator for SOPN at that time contacted the Bureau of Reclamation's Remote Sensing and Geographic Information Group (RSGIG) requesting a proposal for creating vegetation spatial databases for three park units in the SOPN. These parks included Fort Larned National Historic Site, Washita Battlefield National Historic Site, and Lyndon B. Johnson National Historical Park. In addition San Antonio Missions National Historical Park in the Gulf Coast Network was added due to its proximity to Lyndon B. Johnson National Historic Park. All four units totaled approximately 11,800 acres and included a 0.25-mile buffer into the surrounding environs. Upon acceptance of the RSGIG proposal work was started by acquiring existing imagery and visiting the respective sites. In conjunction with the mapping portion, experienced ecologists were contracted by SOPN to collect vegetation sample plots and observation points. These data were used by NatureServe to classify the vegetation to the association and alliance levels of the National Vegetation Classification System (NVCS). For WABA the ecological sampling was conducted by Roger Sanders, formerly with the Botanical

Research Institute of Texas. After the project was started, Dan Cogan the principal investigator left the BOR to start his own company, Cogan Technology Inc (CTI). All of the subsequent mapping and GIS work was sub-contracted to CTI through existing contracts with Science Applications International Corp.

Together CTI, BRIT, NatureServe, BOR, SOPN and WABA formed a team, each responsible for a specific portion of the project as outlined in the program standards and flowchart provided by the Center for Biological Informatics (USGS/BRD) (Appendix A). BRIT and SOPN took the lead in collecting the standardized field samples and writing the field key and descriptions for the natural and semi-natural vegetation types. They also helped cross-walk the associations/alliances to map classes. NatureServe's Midwest Regional Office was tasked with training the BRIT field personnel in the standardized field collection techniques, classifying the field data, using the NVC, and reviewing the vegetation descriptions, field key, and vegetation database. CTI and BOR were responsible for the imagery interpretation and creating a digital vegetation map and spatial database. SOPN and WABA staff reviewed and evaluated the draft classification, entered field data into a database, and wrote and field-tested the key to the vegetation classification. WABA staff also provided logistical and technical support, and helped coordinate activities.

The objectives of this team were to produce final products consistent with the national program's mandates. These included:

- A Vegetation Classification based on the National Vegetation Classification System;
- A Map Unit Classification based on WABA-specific requirements;
- A spatial database of WABA's vegetation, using remote sensing and GIS techniques;
- Digital and hard copy vegetation maps with a minimum 80% accuracy per map class.

Scope of Work

Vegetation mapping for WABA occurred within an approximate 924 acre project area. The boundary encompassed both the boundary of WABA and a general 0.25-mile environ radius around the site. The final project area determination was based on management needs, financial constraints, and time limitations (Figure 2).

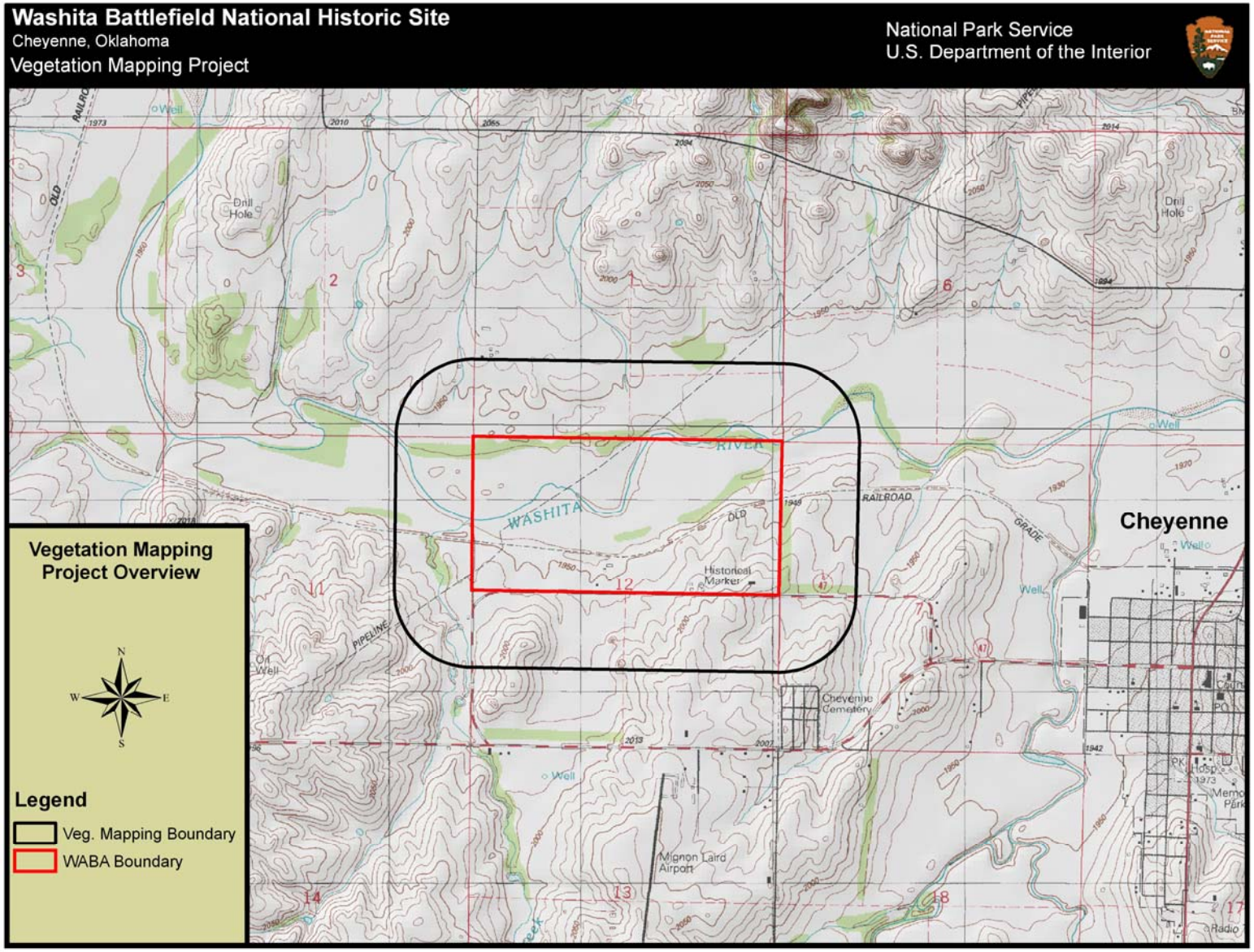

Figure 2. Map of the vegetation project boundary and park boundary.

Methods

The vegetation mapping project at WABA was considered to be in the "medium park" category based on the overall size of the project area (TNC 1994b). As such, the standard methodology for sampling and mapping is to visit the entire park and select representative sites. It is assumed that these sites will sufficiently characterize the vegetation types and explain their distribution across the park without having to survey each stand of vegetation. Based on this approach the assignment of responsibilities was divided into five major steps following the flowchart of major steps produced for the national program by the USGS (Appendix A). These responsibilities included the following:

1. Plan, gather data, and coordinate tasks;
2. Survey WABA 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;
4. Acquire current digital imagery and interpret the vegetation from these using the classification scheme and a map unit crosswalk;
5. Assess the accuracy of the final map product.

All protocols for this project as outlined in the following sections can be found in documents produced by The Nature Conservancy (1994a, 1994b, and 1994c) for the USGS-NPS Vegetation Mapping Program and are found at this website: http://biology.usgs.gov/npsveg.

Planning, Data Gathering and Coordination

A series of planning conference calls were held throughout 2005 attended by representative USGS, NPS, NatureServe, BOR, and SOPN staff. The goals of these calls were to (1) inform the SOPN/WABA staff about the National Vegetation Mapping program, (2) learn about the park's management issues and concerns, (3) review existing data, (4) develop a schedule and assign tasks, (5) obtain a commitment from SOPN/WABA, (6) define possible cooperation with others, and (7) start defining a project boundary.

These calls in addition to follow-up meetings, conference calls and e-mails helped determine the project boundary and base imagery. As stated above, the final project boundary included a modest ¼ mile environs due to financial constraints (Figure 2). Once the boundary was finalized all of the latest NAIP imagery for this area was ordered from the USDA Geospatial Gateway website (http://datagateway.nrcs.usda.gov). Imagery included both the county mosaics acquired in 2003, 2004 and 2005 and the corresponding individual quarter quadrangles. Upon review by BOR and CTI, the 2004 imagery was not used for this project since it had a coarse 2-meter pixel resolution. The 2003 had 1-meter pixel resolution, was true color and provided the best detail and the 2005, even though it had 2-meter pixel resolution, was the latest imagery available. Both the 2003 and 2005 imagery were deemed useful for this project.

The remaining work responsibilities were assigned to the following participants:

WABA-SOPN-NPS Responsibilities

- Provide oversight and project funding;
- Supply digital boundary files and ancillary data files;
- Assist with fieldwork and logistical considerations;
- Work with NatureServe to develop the vegetation classification;
- Compile, review, and update drafts of the vegetation map, classification and report;
- Accept the final products and close the project.

BRIT Responsibilities

- Coordinate the field work with WABA;
- Collect representative plot and accuracy assessment data;
- Collect less detailed observations about the draft vegetation map;
- Write descriptions of the vegetation types found at WABA;
- Write a field key to the vegetation types of WABA;
- Write a summary report.

NatureServe Responsibilities

- Work with NPS to develop a vegetation classification for the study area based on the NVC using quantitative analysis and ecological interpretation of the field data;
- Provide guidance regarding the crosswalk of vegetation types to map units;
- Train BRIT staff on the field data collection methods for the project;
- Review the local vegetation descriptions and field key;
- Review the final database containing the field data.

CTI-BOR Responsibilities

- Help with overall project facilitation and coordination;
- Verify vegetation and land use/land cover signatures on the imagery;
- Develop map units linked to the NVC;
- Provide field maps and GIS support to the field crews;
- Interpret and delineate the final vegetation and land-use types;
- Transfer and automate interpreted data to a digital spatial database;
- Produce spatial layers of plot and accuracy assessment site locations;
- Assist with the accuracy assessment by picking the stratified random target points, creating field maps and providing GIS support;
- Provide a final report describing all aspects of the project;
- Provide a visual guide to the photo signatures of each map unit;
- Document FGDC-compliant metadata for all vegetation data.
- Create a DVD with reports, metadata, guides, vegetation classification, plot data, spatial data, the vegetation database (map), graphics, and ground photos.

Field Survey

The field methods used for developing the classification and conducting the accuracy assessment at WABA followed the methodology outlined by the USGS-BRD/NPS Vegetation Mapping Program (TNC 1994b) for medium sized parks. First, NatureServe provided a preliminary list of vegetation associations and alliances from the NVC based on previous studies and local knowledge. The resulting list was initially used to set targets for data collection with each association marked for 3-5 plots. This list was then taken in the field during the summer of 2005 by BRIT botanists who surveyed the entire site for representative stands of vegetation either fitting this list or for new types.

Once a stand of vegetation was located that appeared to be representative of the plant communities in the area a Relevé macroplot was laid out to capture its characteristics. In this manner transitional areas such as ecotones were avoided. Once a plot was laid out data were recorded on a modified plot form (Appendix B). Environmental information included: elevation, slope, aspect, landform, topographic position, soil texture and drainage, hydrologic (flooding) regime, and evidence of disturbance or wildlife use. The unvegetated surface was recorded as percent cover of each of the following: bedrock, litter and duff, wood, bare soil, large rocks (>10 cm), small rocks (0.2-10 cm), sand (0.1-2 mm), lichens, mosses, and fungi. Vegetation structure and species composition were sampled using plots that varied in size depending on the dominant physiognomy of the vegetation. Forest and woodland plots were 400 m^2, while shrubland, dwarf-shrubland, and herbaceous vegetation plots were 100 m^2. Plot dimensions were recorded on the forms and the plot shape usually was square, but was modified to best represent the vegetation (e.g. narrow, linear rectangles for riparian vegetation).

Within each plot, BRIT visually divided the vegetation into strata, with the height and canopy cover of vegetation estimated for each stratum. Physiognomic class, leaf phenology, and type of dominant stratum were recorded. The species of each stratum were then listed and percent canopy cover estimated using a twelve-point cover scale (e.g. <1%, 1-5%, >5-15% …) (Daubenmire 1959). Additional species within the vegetation unit that occurred outside of sampled plots were listed separately. No attempt was made to identify individual non-vascular plant species. Species that were not identifiable in the field were collected for later identification. Species were recorded by scientific epithet familiar to researchers. For plots with trees, the diameter at breast height (DBH) was measured and recorded for trees with DBH greater than 10 cm. Trees with stems 5-10 cm DBH were tallied. Finally, a provisional vegetation type was assigned to the plot.

After all the physiognomic and environmental information was collected researchers used a Garmin GPS receiver to record the plot center. Universal Transverse Mercator (UTM) NAD83 X-Y coordinates and elevation were recorded both manually on the plot forms and stored as waypoints in the GPS receiver. Finally four or five representative photos were taken in each of the cardinal directions for monitoring purposes.

During the summer of 2006 a total of 31 plots were sampled at WABA (Figure 3).

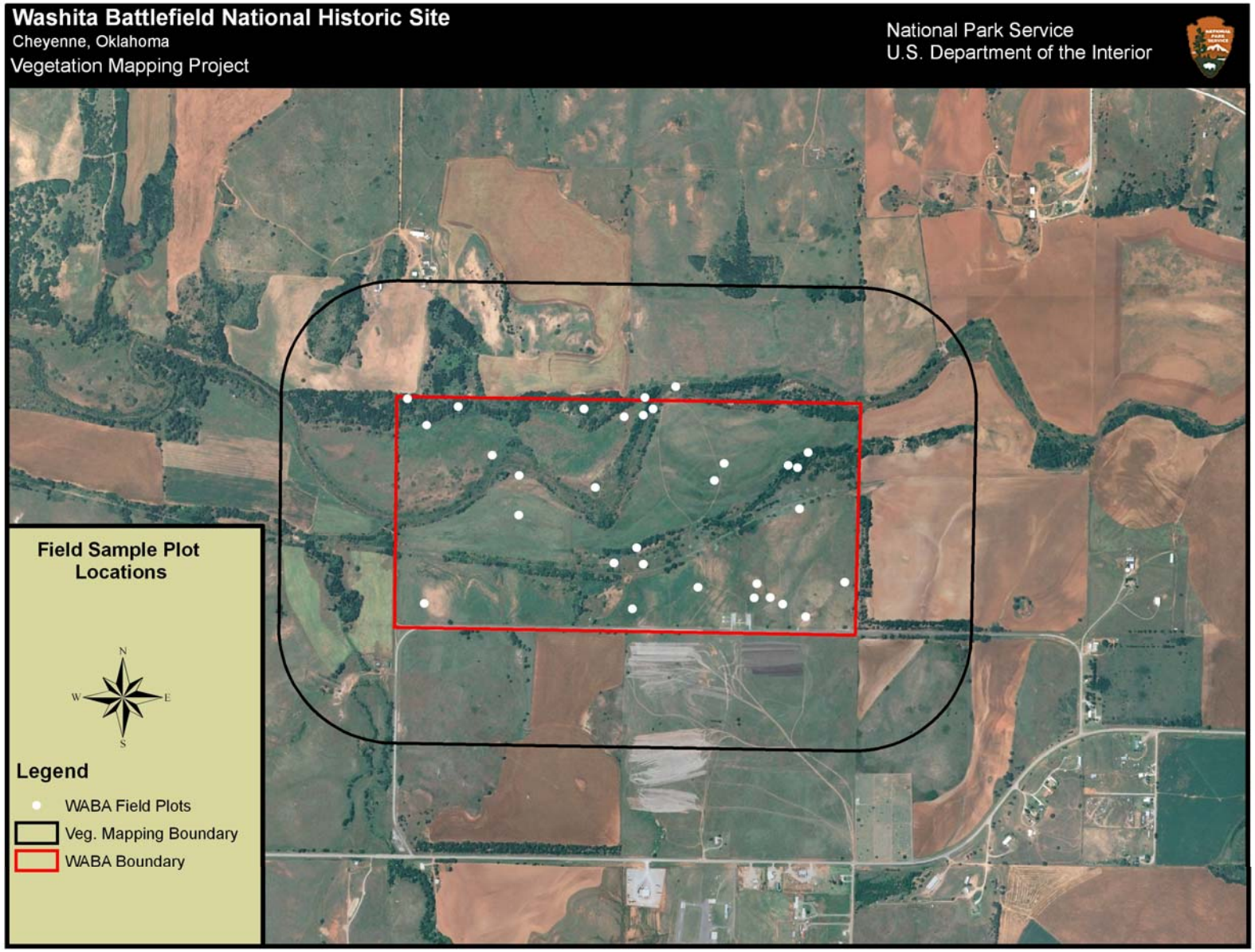

Figure 3. Location of all vegetation plots collected at WABA in 2005.

In addition to the classification plots a number of observation points and incidental points were recorded in the field for signature verification purposes by CTI in 2006 before the accuracy assessment. A formal observation form was completed (Appendix B) for observation points. This form resembled the plot form except that the listing of all the species in the plot and their respective covers were omitted. An incidental point was simply a recording of the dominant vegetation and the X-Y coordinates for its location. A total of 50 observation points and 12 incidental points were recorded at WABA in 2006 (Figure 4).

Vegetation Classification

Upon completion of field surveys, all recorded data were entered into the NPS PLOTS2 database (NatureServe 2005), a MS Access-derived program. The PLOTS2 database was developed specifically for the NPS vegetation and mapping program so that the electronic 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 National Resources Conservation Service in cooperation with the Biota of North America Program (see website at http://plants.usda.gov). After data entry, checking was performed to minimize errors associated with duplicate entries or erroneously selected plant names. Problems regarding unknown species, especially those with high cover, were resolved, as were other taxonomic issues such as grouping subspecies and varieties judged to be ecologically similar.

Prior to quantitative analysis the database was prepared for use in the analytical programs. Data preparation followed these steps:

1). Standardize strata for certain taxa. Some taxa are listed in different strata in different plots even though they should all be the same, especially if there are multiple field crews. For example cacti may sometimes be listed as shrubs and sometimes listed as herbaceous;

2). Create “pseudospecies” for each taxon by appending the stratum in which it was found in each plot to a code for the taxon. For example, *Populus deltoides* (PODE) found in the subcanopy (T3 stratum) would be converted to the code PODET3 for analyses. Seedlings (H stratum) of the same species would be converted to the code PODEH for analyses. These two codes would be treated as separate entities during the quantitative analyses;

3). Simplify the strata for woody species. The strata for trees and shrubs were collapsed from three for each to just one for each. This reduces complexity in the data that does not add to the quality of the classification (though these distinctions do add to the ability to describe the plots and vegetation communities). The field crew might see *Populus deltoides* in the canopy (T2) and subcanopy (T3) in a plot. These two are combined into one “T” stratum observation so that plots are not separated based on fine differences like this;

4). Remove plots with grossly incomplete or missing data.

Figure 4. Location of all observation and incidental points collected at WABA in 2006.

Due to the small size of the park many of the preliminary calls by the field teams to the association were simply matched to existing NVC associations. The remaining types were analyzed in a series of runs in PC-ORD Multivariate Analysis software package (McCune and Mefford 1997) using Indicator Species Analysis (Dufrêne and Legendre 1997, as cited in McCune and Grace 2002). Further analysis using Agglomerative Clustering with Sørensen distance and Flexible beta linkage functions (McCune and Grace 2002) was used to explore each of the indicator groups, and define plant associations. Preliminary plant associations were then compared with the NVC (NatureServe 2006). Throughout, care was taken not to over-emphasize local variations found at WABA compared to more extensive information compiled at the regional level. Nevertheless, several types in the NVC were revised based on these analyses and new associations were identified from WABA's data.

Park ecologists and botanists worked with NatureServe to refine and finalize the classification for WABA. Plant association descriptions and literature references contained within the NVC were compared to WABA results. Quantitative tables of cover and constancy by WABA associations were generated by the PLOTS database, and compared to published tables. Based on qualitative comparisons, some association names were changed, and some plots were moved from one association to another and in some cases new associations were created.

WABA plot data were then used to update and improve the world-wide (i.e. global) descriptions for the associations. WABA specific (i.e. local) descriptions were then written based on WABA plot and AA data. The final WABA classification contains 14 plant associations and alliances. Once the association names were finalized, a dichotomous key was developed for use during the Accuracy Assessment (Appendix C). The full NVC hierarchical classification and local descriptions are available in Appendix D. In addition, the final associations were linked to map classes for use in the photo-interpretation and mapping portions of the project.

Digital Imagery and Interpretation

Since WABA represented a fairly small and accessible site no new imagery or aerial photography was deemed necessary for this project. Instead existing sources of imagery were evaluated and two NAIP products were selected to be used as base maps. Images included the 2003 and 2005 NAIP products (Figure 5). The 2003 had 1-meter resolution and the 2005 had 2-meter resolution. Both were acquired at 1:12,000-scale, which is adequate for vegetation mapping purposes. The 2003 imagery was acquired in true color and at higher resolution that helps highlight subtle differences in vegetation. This type of imagery is useful in separating difficult signatures that occur between different associations in the physiognomic class (i.e. different grasslands or herbaceous vegetation types). The 2005 imagery lacked the resolution of the 2003 imagery but it did highlight all of the recent changes to the landscape such as recent fires, new roads, tree removals, etc. After obtaining both sets of imagery, they were color balanced in ERDAS Imagine software to remove some of the edge-matching issues and sharpen the images. The resulting images from both sets were mosaiced and clipped to just beyond the project boundary.

Figure 5. Examples of the NAIP 2003 and 2005 imagery for WABA.

Interpretation of the vegetation at WABA involved a three step process: 1) image segmentation, 2) cleaning and smoothing, and 3) ground-truthing of the data. First the 2003 imagery was re-sampled to a 3-meter pixel resolution to reduce noise and to generalize the vegetation signatures. Next this imagery was segmented using eCognition software to delineate obvious landforms (e.g. open water and fields) and physiognomic features (e.g. grasslands versus woodlands). The initial segments were created using a series of trial-and-error multi-resolution segmentation routines in the software. The settings for scale and shape were manipulated until a desired network of image objects resulted. The objective of the segmentation was to create a system of lines with as coarse a scale as possible without omitting most of the small, important and obvious land-cover patches. By iteratively increasing segmentation size within the program small image objects (i.e. preliminary polygons) were continuously merged into larger ones. Completion of the segmentation was based on ocular judgment of the analyst when obvious, distinct features were lost. At this point in the process the previous segmentation was adopted as the final treatment.

Following segmentation, the lines were exported as ArcInfo shapefiles and converted to ArcInfo coverages. The resulting coverages were run through a series of smoothing routines provided in the ArcGIS software. Smoothing was conducted to reduce the stair-stepping pattern of the lines resulting from the large pixels. Smoothing ended when no obvious artificial and relict breaks in the lines were visible. Following smoothing, the linework was manually cleaned to remove extraneous lines, small polygons, and polygons that obviously split a homogenous stand of vegetation. The cleaning stage was considered complete when all resulting polygons matched homogenous stands of vegetation apparent on the 2003 imagery

The lines resulting from the 2003 imagery segmentation were visually inspected in ArcInfo comparing them to the more recent 2005 imagery. Any obvious changes in the landscape between the two years were added or edited. Review of the merged polygon layer revealed that the roads and the facilities were not adequately separated from the surrounding vegetation. To

resolve this, all large buildings, roads, streams and other linear and rectangular features were manually digitized directly off the 2005 imagery and incorporated into the final segmentation. After merging the digitized lines with the segmented linework the resulting preliminary GIS layer was considered complete and ready to be ground-truthed in the field.

Once the preliminary vegetation layer for WABA was completed 1:6,000-scale hard copy maps were printed for review. These maps contained both the 2003 and 2005 basemaps and the linework as an overlay. During two days in 2005, researchers from CTI and BOR visited almost every polygon at WABA. In addition more ground-truthing to collected observation points was conducted in 2006. Ground-truthing consisted of verifying the maps against the actual vegetation on the ground to ensure that the polygons were labeled properly and to locate any extra or missing vegetation polygons. More general observations were also taken during this trip to help write descriptions for this report and create map units. All the information from this trip was subsequently added to the final GIS layer to correct any errors.

After returning from the field, CTI researchers used the final NVC classification supplied by NatureServe to create map units. In most cases the map units were derived on a 1 association or 1 alliance to 1 map unit basis. Due to the limitations of the imagery some of the associations could not be recognized consistently. This issue was addressed by scaling up the NVC to the alliance level. All of the resulting map units were then correlated or "crosswalked" by noting when plant associations were lumped into a single map unit or when associations were split into multiple map units. To round-out the mapping scheme, map units were created for land-use types based on a mapping system developed by Anderson et al.(1976). This includes all of the unvegetated lands not included in the NVC, such as roads, facilities, and agricultural fields. A separate class of map modifiers or "Park Specials" was also defined especially for WABA to cover types that occurred either as small stands or were located outside of the park boundary. This effort included false indigo, Siberian elm, smooth sumac, and gumbully stands. All of the resulting map unit names, map unit codes, NVC information, and other relevant attributes were added to each polygon in the GIS layer (Table 1).

Pictures of the Washita River (left) and the uplands at WABA (right).
Photographs by: Roger Sanders

Table 1. Polygon attribute items and descriptions used in the WABA GIS coverage.

ATTRIBUTE	DESCRIPTION
AREA*	Surface area of the polygon in meters squared
PERIMETER*	Perimeter of the polygon in meters
WABA_VEG#*	Unique code for each polygon
WABA_VEG-ID*	Unique identification code for each polygon
MAP_CLASS	Final Map Unit Codes – Project specific
MAP_DESC	Map Unit Common Description Name – Project specific
DENS_MOD	Modifier - Percent cover of the upper stratum layer in the polygon Percent cover classes: Sparse **10 - 25%,** Open **25 - 60%,** Discontinuous - Closed > **60%**
PTRN_MOD	Modifier - Vegetation pattern within the polygon Vegetation pattern classes: Evenly Dispersed **= Homogeneous, Alternating,** Grouped Stands of Vegetation = **Bunched / Clumped,** String of Vegetation **= Linear**
HT_MOD	Modifier - Height range of the dominant vegetation layer Height classes: **0-0.5, 0.5-1, 1-5, 5-15, 15-30 meters**
CES_CODE	Ecological Systems Code – NVC derived (NatureServe)
CES_NAME	Ecological Systems Name – NVC derived (NatureServe)
IDENTIFIER	Corresponding Association or Alliance Name Code – NVC derived (NatureServe) Association **=** Community Element Global Code – Elcode link to the NVC Alliance = Alliance Global Code – Alliance Link to the NVC
ASSN_NAME	Project Community Name - NVC Association(s)
ASSN_CNAME	Project Common Community Name - synonym name of Association(s)
NVCS_CODE	NVC Code - to NVC Formation level
ALL_NAME	Project Alliance Name = NVC Alliance(s)
ALL_CNAME	Project Common Alliance Name = NVC Alliance(s)
FORMATION	NVC Formation = Formation name NVC Code – Formation name
SUBGROUP	NVC Formation Subgroup = NVC Code – Subgroup name
GROUP	NVC Formation Group = NVC Code – Group name
SUBCLASS	NVC Formation Subclass = NVC Code – Subclass name
CLASS	Formation Class = NVC Code – Class name
LUC_II_GEN	General Land Use and Land Cover Classification System Name – Project specific based on Level II of Anderson et al. (1976)
LUC_II	Specific Land Use and Land Cover Classification System Name – Project specific Level II of Anderson et al. (1976)
COMMENTS	General comments about the vegetation in the polygon
ACRES	Surface area of the polygon in acres

(*****ArcInfo© default items)

Accuracy Assessment

Once the vegetation layer was completed and finalized, the accuracy assessment (AA) was conducted. Typically in mapping exercises both thematic or attribute map accuracy as well as the positional or polygon line accuracy are considered. In the case of the USGS-NPS National Vegetation Mapping Program however, the positional accuracy is usually omitted since rarely does vegetation split on discrete edges that can be positively located in the field. The subjectivity involved in this effort plus the high resolution and accuracy of the NAIP basemaps usually allows for the assumption that all products derived from them are well within National Map Accuracy Standards for 1:12,000-scale maps (±30 feet). Further since no additional funding was budgeted or available the positional accuracy was not assessed.

The thematic accuracy of the vegetation map was assessed and the methodology followed the standards provided by the USGS-NPS National Vegetation Mapping Program's Accuracy Assessment Procedures manual (TNC 1994c). The methods included a four step process consisting of a sample design, sample site selection, data collection and data analysis. The design of the AA process followed the five possible scenarios provided in the field manual with stratified random targets placed in each map class based on their respective frequency and abundance (Table 2).

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

Scenario	Description	Polygons in class	Area occupied by class	Recommended number of samples in class
Scenario A:	The class is abundant. It covers more than 50 hectares of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.	> 30	> 50 ha	30
Scenario B:	The class is relatively abundant. It covers more than 50 hectares of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.	< 30	> 50 ha	20
Scenario C:	The class is relatively rare. It covers less than 50 hectares of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.	> 30	< 50 ha	20
Scenario D:	The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 hectares of the area. In this case, the recommended number of samples is 5. The rationale for reducing the sample size is that the class consists of small polygons and the frequency of the polygons is low. Specifying more than 5 sample sites will therefore probably result in multiple sample sites within the same (small) polygon. Collecting 5 sample sites will allow an accuracy estimate to be computed, although it will not be very precise.	.5, 30	<50 ha	5
Scenario E:	The class is very rare. It has fewer than 5 polygons and occupies less than 50 hectares of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon) no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).	< 5	< 50 ha	Visit all and confirm

These parameters were entered into a custom GIS program along with the vegetation layer. This program picked the random target locations and also buffered them 10 meters away from any polygon boundary and 50 meters away from any other point. Being able to choose minimum distance to polygon boundaries helped to minimize confusion and accounted for the horizontal error typically encountered in common GPS receivers (±5 m). The resulting target locations were restricted to within the boundaries of WABA due to private land access constraints.

Once the target locations were selected BRIT botanists were provided with draft field maps, overview maps, map unit definitions, the key to the associations (Appendix C), and digital GPS files containing the location of the target AA sites. During the summer of 2006 the botanists traveled to the AA target sites and determined the vegetation association using the key. At each target they recorded the primary and secondary associations that occurred within a roughly 50-meter radius. They also recorded height and cover of vegetative strata, environmental data, and percent canopy cover of the major species (see AA point form in Appendix B). Other nearby vegetation types outside the 50-meter radius and any recent disturbance were also recorded. To better assist the analysis a minimum of 4 photographs were taken at each AA point, in the sequence of cardinal directions, N-E-S-W. If the point was too close to dense, especially shrubby vegetation, one or more optional photographs were taken at a distance to show the character of the vegetation. In such cases, the site of the optional photograph was recorded as UTM coordinates and the aspect of the photograph entered for that point.

During 2006 a total of 105 AA points were sampled (Figure 6). The data recorded on the field forms were subsequently entered into the PLOTS2 database and reviewed for data entry errors by NPS and NatureServe staff. Incomplete data on the field sheets were corrected if possible. The results were imported from the database into a GIS layer where they were visually compared in two stages to the vegetation map coverage. The first step was to compare the AA points to the original target locations to check for erroneous points and remove these from further analysis. General errors in the data were recorded at this time, including documenting points that had UTM coordinate and location errors. The most common GPS receiver error included transposing two UTM coordinate numbers. Location errors involved having the final AA point occur in the wrong target polygon either due to bad GPS receiver positioning or the point occurred too close to a polygon boundary. Through this process all of the AA points at WABA were determined to be located in the correct target polygon.

The second review step involved deciding between the primary and secondary call for the plant association as recorded by the field crew. In larger vegetation mapping projects such as Rocky Mountain National Park (Salas et al. 2004), AA analysis has involved fuzzy logic which assigns different levels of accuracy based on the primary, secondary and sometimes even the tertiary calls. However due to the small size of this project and the confusion that fuzzy logic can cause for the end user, a simple binary assessment was conducted. To accomplish this, CTI assigned a final map unit for every point by choosing between the primary and secondary calls. This was accomplished by first adding a new attribute to the point layer labeled “Final_Code” and then by comparing the assigned field names of the point with its corresponding location on the digital imagery. In most cases the primary vegetation map unit name assigned by the field crew was used. However some points were assigned their secondary field call based on one of the following reasons: 1) it appeared that the second call was the better choice due to the overhead

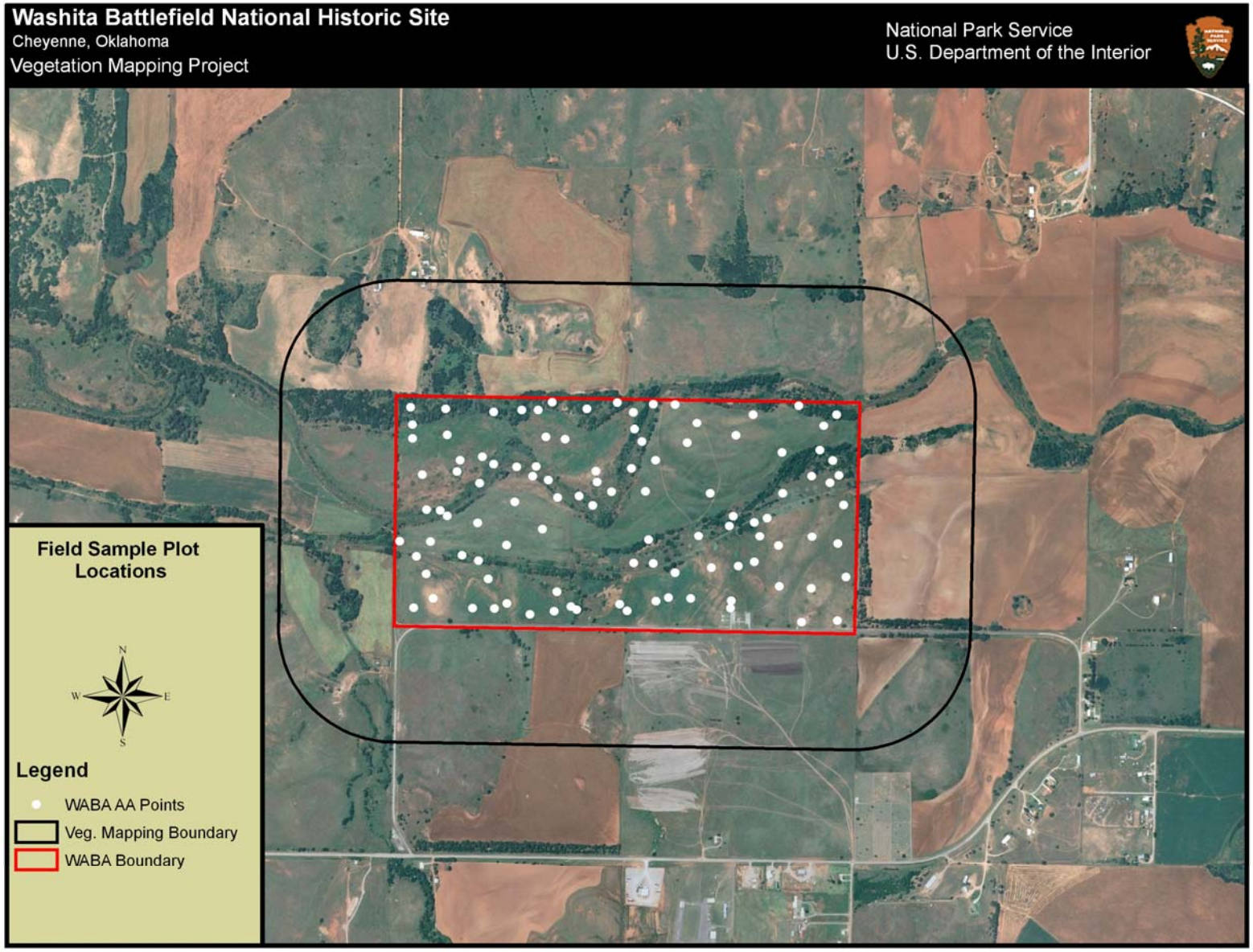

Figure 6. Location of all accuracy assessment points collected at WABA in 2006.

perspective (e.g. a stand judged to be sparse woodland on the imagery vs. called herbaceous vegetation in the field), 2) the data were actually recorded in a stand that was too small (i.e. inclusion), or 3) the second call better matched the ecological context (e.g. riparian woodland located next to a stream vs. upland woodland located next to a stream). Overall, roughly 10-20 points were reassigned to their secondary field call instead of their primary identification.

Once the data were reviewed the accuracy analysis was completed. In the case of WABA, the process was streamlined using methods developed from previous studies at Rocky Mountain National Park (Salas et al. 2004) and Wupatki National Monument (Hansen et al. 2004). Specifically many of the in-house GIS programs developed for these projects were used to compare the AA data, generate confidence intervals, Kappa statistics, and error matrices (contingency tables). Through this automated process, the final map units in the AA layer were compared to the map unit designations for their corresponding polygons. All of the statistics and calculations used to analyze these data are described at length in the program manuals (TNC 1994c) and are summarized in Table 3. Final assessments for each point were recorded using an error matrix.

Table 3. Summary of the AA Statistics used at WABA.

Statistic	Formula	Description
User's - accuracy:	$\frac{n_{ii}}{n_{i+}}$	Where i is the land cover type, n_{ii} is the number of matches between map and reference data and n_{i+} is the total number of samples of i in the map. This formula is the number of "correct" observations divided by the sum of the column
Producer's accuracy	$\frac{n_{ii}}{n_{+i}}$	Where n_{+i} = total number of sample of i in the reference data. This formula is the number of "correct" observations divided by the sum of the row
Confidence Interval	$\hat{p} \pm \left\{ z_\alpha \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} + \frac{1}{(2n)} \right\}$	Where z_α = 1.645 (this comes from a table of the z-distribution at the significance level for a two-sided limit with a 90% confidence interval). The term 1/ (2n) is the correction for continuity. The correction should be applied to account for the fact the binomial distribution describes discrete populations $\hat{p}$ = the sample accuracy (0 -1.0), n = the number of sites sampled.
Kappa Index	$k = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum(x_{i+} \times x_{+i})}$	Where N is the total number of sites in the matrix, r is the number of rows in the matrix, x_{ii} is the number in row i and column i, x_{+i} is the total for row i, and x_{i+} is the total for column I.

Results

Vegetation Classification

The final classification for WABA resulted in 8 associations and 3 alliances, 1 of which was newly described in the NVC. In addition, during ground-truthing efforts CTI described 4 additional alliances, 1 association and 4 distinctive stands of vegetation (i.e. Park Specials) that primarily occurred outside of the park boundary in the environs. The classification results reflect both the moderate amount of diversity of vegetation in the park and a respectably high number of native species. Table 4 contains the complete list of WABA plant associations and alliances that were described in this study and Appendix D provides complete descriptions for each. During the sampling efforts a total of 162 species were recorded (Appendix E).

Digital Imagery and Interpretation

For WABA, 27 map units were developed and directly cross-walked or matched to corresponding plant associations and land-use classes (Table 5). These relationships included mostly a direct 1 map unit to 1 NVC association/alliance relationship. Since the park special map units were not classified to the NVC they do not typically have a corresponding NVC association or alliance. Please reference Appendix F for detailed descriptions and representative photos for all vegetation map units.

Relationship between Map Units and Plant Associations/Alliances

The WABA map units represent a compromise between the detail of the NVC, the needs of the park and the limitations of the imagery. As a result, the mapping scheme does not exactly match the NVC. Rather, the vegetation map units are linked (i.e. “crosswalked”) to the NVC plant associations or alliances when possible. When the NVC link was not feasible other map units were created.

The following were the possible map scenarios that were encountered at WABA: (1) when a plant association or alliance had a unique photo signature and could be readily delineated on the photos, the map unit adopted the plant association/alliance name. This was considered a one-to-one relationship. (2) When unique stands of vegetation did not have a corresponding NVC association or alliance these were considered “park specials”. (3) Finally, non-vegetated areas and vegetation types not recognized by the NVC received Anderson et al. (1976) Land Use – Land Cover map unit designations.

Table 4. List of NVC Plant Associations and Alliances found at WABA.

Scientific Name	**Common Name**	**Elcode**[1]
Forest and Woodlands		
Populus deltoides – Ulmus americana – Celtis laevigata Forest	Eastern Cottonwood - American Elm - Sugarberry Forest	CEGL002090
Sapindus saponaria Woodland	Western Soapberry Woodland	CEGL004535
Shrublands		
Prunus angustifolia Shrubland Alliance	Chickasaw Plum Shrubland Alliance	A.1884
**Artemisia filifolia / Andropogon hallii* Shrubland	Sand Sagebrush / Sand Bluestem Shrubland	CEGL001459
**Salix nigra* Temporarily Flooded Shrubland Alliance	Black Willow Temporarily Flooded Shrubland Alliance	A.948
Herbaceous Vegetation		
Andropogon hallii - Calamovilfa gigantea Herbaceous Vegetation	Sand Bluestem - Big Sandreed Herbaceous Vegetation	CEGL004016
Andropogon gerardii - Sorghastrum nutans Western Great Plains Herbaceous Vegetation	Big Bluestem – Yellow Indiangrass Western Great Plains Herbaceous Vegetation	CEGL001464
Schizachyrium scoparium - Bouteloua curtipendula Western Great Plains Herbaceous Vegetation	Little Bluestem - Sideoats Grama Western Great Plains Herbaceous Vegetation	CEGL001594
Pascopyrum smithii Herbaceous Alliance	Western Wheatgrass Herbaceous Alliance	A.1554
Bouteloua gracilis - Bouteloua curtipendula Herbaceous Vegetation	Blue Grama - Sideoats Grama Herbaceous Vegetation	CEGL001754
Iva annua - (Xanthium strumarium) Temporarily Flooded Herbaceous	Sumpweed - (Cocklebur) Temporarily Flooded Herbaceous Vegetation	CEGL00XXXX
Schoenoplectus pungens - Paspalum distichum Herbaceous Vegetation	Threesquare - Joint Crowngrass Herbaeous Vegetation	CEGL005989
Bromus tectorum Semi-Natural Herbaceous Alliance	Cheatgrass Semi-Natural Herbaceous Alliance	A.1814
**Panicum virgatum* Temporarily Flooded Herbaceous Alliance	Switchgrass Temporarily Flooded Herbaceous Alliance	A.1343
**Sorghum halepense* Herbaceous Alliance	Johnsongrass Herbaceous Alliance	A.2020
**Cynodon dactylon* Herbaceous Alliance	Bermuda Grass Herbaceous Alliance	A.1279

*Represents discrete stands of vegetation that were not sampled either due to their small size or they occurred outside of the park boundary.
[1] **ELCODE** represents NatureServe's internal database tracking code for each recognized plant association or alliance.

Table 5. Map units identified in WABA.
The units are organized into ecological groups. "Level" refers to whether the map unit represents a NVC plant association/alliance (NVC unless otherwise noted) or a local plant community/plant population (Park Special), or a land use class. Anderson Land Use Classes are identified by Roman numerals.

Map Code	Map Unit Name	Map Unit Common Name	Level
Forest and Woodlands			
F-COTW	*Populus deltoides* - *Ulmus americana* - *Celtis laevigata* Forest	Eastern Cottonwood - American Elm - Sugarberry Forest	Association
W-WTSB	*Sapindus saponaria* Woodland	Western Soapberry Woodland	Association
W-SELM	**Ulmus pumila* Woodland Stand	Siberian Elm Woodland Stand	Park Special
W-GUMB	**Sideroxylon lanuginosum* Woodland Stand	Gumbully Woodland Stand	Park Special
Shrublands			
S-CHPM	*Prunus angustifolia* Shrubland Alliance	Chickasaw Plum Shrubland Alliance	Alliance
S-SMSU	**Rhus glabra* Shrubland Stand	Smooth Sumac Shrubland Stand	Park Special
S-BLWL	*Salix nigra* Temporarily Flooded Shrubland Alliance	Black Willow Temporarily Flooded Shrubland Alliance	Alliance
S-SSAG	*Artemisia filifolia* Shrubland Alliance	Sand Sagebrush / Sand Bluestem Shrubland	Association
S-INDG	**Amorpha fruticosa* Shrubland Stand	False Indigo Shrubland Stand	Park Special
Herbaceous Vegetation			
H-SAND	*Andropogon hallii* - *Calamovilfa gigantea* Herbaceous Vegetation	Sand Bluestem - Big Sandreed Herbaceous Vegetation	Association
H-BIGB	*Andropogon gerardii* - *Sorghastrum nutans* Western Great Plains Herbaceous Vegetation	Big Bluestem – Yellow Indiangrass Western Great Plains Herbaceous Vegetation	Association
H-LITB	*Schizachyrium scoparium* - *Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation	Little Bluestem - Sideoats Grama Western Great Plains Herbaceous Vegetation	Association
H-WTWG	*Pascopyrum smithii* Herbaceous Alliance	Western Wheatgrass Herbaceous Alliance	Alliance

H-BLGR	*Bouteloua gracilis* - *Bouteloua curtipendula* Herbaceous Vegetation	Blue Grama - Sideoats Grama Herbaceous Vegetation	Association
H-SUMP	*Iva annua* - *(Xanthium strumarium)* Temporarily Flooded Herbaceous	Sumpweed - (Cocklebur) Temporarily Flooded Herbaceous Vegetation	Association
H-THSQ	*Schoenoplectus pungens* - *Paspalum distichum* Herbaceous Vegetation	Threesquare - Joint Crowngrass Herbaeous Vegetation	Association
H-CEAT	*Bromus tectorum* Semi-Natural Herbaceous Alliance	Cheatgrass Semi-Natural Herbaceous Alliance	Alliance
H-SWGR	*Panicum virgatum* Temporarily Flooded Herbaceous Alliance	Switchgrass Temporarily Flooded Herbaceous Alliance	Alliance
H-JOHN	*Sorghum halepense* Herbaceous Alliance	Johnsongrass Herbaceous Alliance	Alliance
H-BERM	*Cynodon dactylon* Herbaceous Alliance	Bermuda Grass Herbaceous Alliance	Alliance
Land Use – Land Cover			
L-STRM	(No Scientific Name)	Stream / River	Level III
L-POND	(No Scientific Name)	Lake / Pond	Level III
L-AGRI	(No Scientific Name)	Agricultural Business	Level III
L-ROAD	(No Scientific Name)	Transportation	Level III
L-FACL	(No Scientific Name)	Park Facilities	N/A
L-TRAN	(No Scientific Name)	Transitional	Level II
L-FILD	(No Scientific Name)	Planted / Cultivated	Level III

*Park Special: Represents discrete stands of vegetation that were too small and/or occurred too infrequently to classify.

Below is a comprehensive breakdown of the crosswalking of the NVC associations to the map units for WABA:

-Map Units Representing Single NVC Units (either existing or new)
(One Alliance/Association-to-One Map Class)

The following map units were created from the NVC and represent established or provisional plant alliances that could be discerned and delineated on the imagery.

Map Code	Map Unit *NVC Plant Alliance / Association(s)*
F-COTW	*Populus deltoides - Ulmus americana - Celtis laevigata* Forest *Populus deltoides – Ulmus americana – Celtis laevigata* Forest
W-WTSB	*Sapindus saponaria* Woodland *Sapindus saponaria* Woodland
S-CHPM	*Prunus angustifolia* Shrubland Alliance *Prunus angustifolia* Shrubland Alliance
S-BLWL	*Salix nigra* Temporarily Flooded Shrubland Alliance *Salix nigra* Temporarily Flooded Shrubland Alliance
S-SSAG	*Artemisia filifolia* Shrubland Alliance *Artemisia filifolia* Shrubland Alliance
H–SAND	*Andropogon hallii - Calamovilfa gigantea* Herbaceous Vegetation *Andropogon hallii - Calamovilfa gigantea* Herbaceous Vegetation
H–BIGB	*Andropogon gerardii - Sorghastrum nutans* Western Great Plains Herbaceous Vegetation *Andropogon gerardii - Sorghastrum nutans* Western Great Plains Herbaceous Vegetation
H–LITB	*Schizachyrium scoparium - Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation *Schizachyrium scoparium - Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation
H–WTWG	*Pascopyrum smithii* Herbaceous Alliance *Pascopyrum smithii* Herbaceous Alliance

H–BLGR *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation
Bouteloua gracilis - Bouteloua curtipendula Herbaceous Vegetation

H–SUMP *Iva annua - (Xanthium strumarium)* Temporarily Flooded Herbaceous
Iva annua - (Xanthium strumarium) Temporarily Flooded Herbaceous

H–THSQ *Schoenoplectus pungens - Paspalum distichum* Herbaceous Vegetation
Schoenoplectus pungens - Paspalum distichum Herbaceous Vegetation

H–CEAT *Bromus tectorum* Semi-Natural Herbaceous Alliance
Bromus tectorum Semi-Natural Herbaceous Alliance

H–SWGR *Panicum virgatum* Temporarily Flooded Herbaceous Alliance
Panicum virgatum Temporarily Flooded Herbaceous Alliance

H–JOHN *Sorghum halepense* Herbaceous Alliance
Sorghum halepense Herbaceous Alliance

H–BERM *Cynodon dactylon* Herbaceous Alliance
Cynodon dactylon Herbaceous Alliance

-Map Units Representing No Association

These map units were created for WABA to describe vegetation that had no corresponding NVC association for the following reason:

Local Stands - Represents infrequent or rare types that were observed primarily in the environs during the photo interpretation and could not be classified to an association since no plots or points were collected;

Map Code	Map Unit
W-SELM	*Ulmus pumila* Woodland Stand (Local Stands)
W-GUMB	*Sideroxylon lanuginosum* Woodland Stand (Local Stands)
S-SMSU	*Rhus glabra* Shrub Herbaceous Alliance (Local Stands)
S-INDG	*Amorpha fruticosa* Shrubland Stand (Local Stands)

Vegetation Map

Just over 924 acres including 320 acres in the current (i.e. actual) boundary of WABA and an additional 604 acres in the environs were mapped using 27 map classes. This included 7 land cover classes and 20 vegetation classes. Of all the map units, the most frequent was Eastern Cottonwood - American Elm - Sugarberry Forest with 53 polygons. The most abundant map unit in terms of area was Big Bluestem – Yellow Indiangrass Western Great Plains Herbaceous Vegetation covering 217 acres (87 hectares) or about 23% of the project area. All of the frequencies for each map units (i.e., number of polygons) along with acreage per map unit are listed in Table 6.

Normally the standard minimum mapping unit for NPS vegetation mapping projects is defined as 0.5 hectare. However this is nominal unit and due to the small size of WABA and the resolution of the imagery it was reduced to ¼ acre. This size allowed for more detail in the mapping and allowed for better delineation of important stands of vegetation such as wetlands, weedy patches and riparian vegetation. This ability to recognize small patches of vegetation is reflected in the high number of polygons created (390) and the average size of the polygons for this project, ~2.4 acres (1 hectare).

Accuracy Assessment

The 2006 AA effort yielded 105 points that were distributed throughout WABA with none sampled in the environs due to access constraints. In addition to their use in the AA analyses many of the points were also used to update the classification and to revise the local descriptions. This helped strengthen the overall classification for both WABA and added to the global perspective of the individual associations/alliances.

Actual analysis of the AA points involved a point-by-point review in two stages. During stage one, an AA GIS point file was created from the AA point coordinates recorded in the field. These were then overlaid on the vegetation map and a comparison of the final AA field call versus the vegetation polygon label was conducted by CTI staff. This analysis resulted in a preliminary error matrix that was sent to SOPN for review. The first binary assessment revealed an overall accuracy of 88% with 6 map classes below the 80% standard. However SOPN deemed these classes important for management and the accuracy was low for these classes due to the small sample size. Based on their recommendations the vegetation GIS layer was accepted and the preliminary analysis was finalized (Table 7).

Examination of the final error matrix (Table 7) shows that areas of confusion were found between similar herbaceous and shrub types. For example the Johnsongrass herbaceous type was confused with the Switchgrass herbaceous type one time and the Chickasaw Plum shrubland was confused with the Black Willow shrubland type. These results are likely an overlap in common species between the types and the fact that large areas of the park are being restored from early seral communities to native grasslands. Other errors in the map can be explained by the difficulty in resolving the difference in scale and perspective between viewing the vegetation on the imagery and assessing it on the ground. For example, sampling could have occurred in inclusions or openings in woodland canopies and documented smaller units than were mapped.

Table 6. Total acreage and frequency of map units for WABA.

Map Code	Map Unit Description	Park (Actual Park Boundary)			Total Project Area		
		Frequency	Acres	Hectares	Frequency	Acres	Hectares
F-COTW	Eastern Cottonwood - American Elm - Sugarberry Forest	29	20.6	8.3	53	54.5	22.1
W-WTSB	Western Soapberry Woodland	22	23.9	9.7	33	41.2	16.7
W-SELM	Siberian Elm Woodland Stand	8	3.3	1.3	18	16.9	6.8
W-GUMB	Gumbully Woodland Stand	1	0.9	0.4	1	1.4	0.6
S-CHPM	Chickasaw Plum Shrubland Alliance	15	7.1	2.9	33	22.7	9.2
S-SMSU	Smooth Sumac Shrub Herbaceous Alliance	3	0.5	0.2	4	1.0	0.4
S-BLWL	Black Willow Temporarily Flooded Shrubland Alliance	5	5.2	2.1	7	8.5	3.4
S-SSAG	Sand Sagebrush / Sand Bluestem Shrubland	5	7.2	2.9	5	7.2	2.9
S-INDG	False Indigo Shrubland Stand	1	0.2	0.1	3	1.2	0.5
H-SAND	Sand Bluestem - Big Sandreed Herbaceous Vegetation	14	12.4	5.0	24	25.6	10.4
H-BIGB	Big Bluestem – Yellow Indiangrass Western Great Plains Herbaceous Vegetation	11	67.7	27.4	20	217.3	88.0
H-LITB	Little Bluestem - Sideoats Grama Western Great Plains Herbaceous Vegetation	10	40.0	16.2	12	65.2	26.4
H-WTWG	Western Wheatgrass Herbaceous Alliance	13	16.8	6.8	16	24.8	10.0
H-BLGR	Blue Grama - Sideoats Grama Herbaceous Vegetation	20	22.5	9.1	31	49.3	20.0
H-SUMP	Sumpweed - (Cocklebur) Temporarily Flooded Herbaceous Vegetation	27	24.4	9.9	36	41.1	16.6
H-THSQ	Threesquare - Joint Crowngrass Herbaeous Vegetation	3	0.1	0.0	11	2.3	0.9
H-CEAT	Cheatgrass Semi-Natural Herbaceous Alliance	10	35.6	14.4	22	75.7	30.7
H-SWGR	Switchgrass Temporarily Flooded Herbaceous Alliance	13	11.3	4.6	16	12.1	4.9
H-JOHN	Johnsongrass Herbaceous Alliance	9	7.7	3.1	12	9.3	3.8
H-BERM	Bermuda Grass Herbaceous Alliance	4	5.1	2.1	4	5.5	2.2
L-STRM	Stream / River	3	3.1	1.3	1	6.7	2.7
L-POND	Lake / Pond	0	0.0	0.0	1	0.3	0.1
L-AGRI	Agricultural Business	0	0.0	0.0	4	5.0	2.0
L-ROAD	Transportation	1	4.2	1.7	1	6.0	2.4
L-FACL	Park Facilities	3	0.0	0.0	3	0.0	0.0
L-TRAN	Transitional	0	0.0	0.0	2	30.3	12.3
L-FILD	Planted / Cultivated	3	0.0	0.0	10	192.9	78.1
Total Land-Use / Land Cover		10	7.3	3.0	22	241.2	97.7
Total Natural Vegetation		223	312.5	126.6	361	682.8	276.5
Totals		**233**	**319.8**	**129.5**	**383**	**924.0**	**374.2**

Instructions on Using the Accuracy Assessment Contingency Table:

The contingency table or error matrix found on the next page presents an array of numbers set out in rows and columns corresponding to a particular vegetation map unit relative to the actual vegetation type as verified on the ground. The column headings represent the vegetation classification as determined in the field and the row headings represent the vegetation classification taken from the vegetation map. The highlighted diagonal indicates the number of points assessed in the field that agree with the map label. Conversely, the inaccuracies of each map unit are described as both errors of inclusion (user's or commission errors) and errors of exclusion (producer's or omission errors). By reading across this table (i.e., rows) one can calculate the percent error of commission, or how many polygons for each map unit were incorrectly labeled when compared to the field data. By reading down the table (i.e., columns) one can calculate the percent error of omission, or how many polygons for that type were left off the map. Numbers "on the diagonal" tell the user how well the map unit was interpreted and how confident they can be in using it. Numbers "off the diagonal" yield important information about the deficiencies of the map including which types were: 1) over- mapped - commission errors on the right or 2) under-mapped - omission errors on the bottom

Table 7. Contingency table (error matrix) for vegetation mapping at WABA.

	Reference Data (Accuracy Assessment Field Data)																				User's Error		
Sample Data (Polygon Map Data)	Map Units	F-COTW	W-WTSB	W-SELM	W-GUMB	S-CHPM	S-SMSU	S-BLWL	S-SSAG	S-INDG	H-SAND	H-BIGB	H-LITB	H-WTWG	H - BLGR	H-SUMP	H-CEAT	H-SWGR	H-JOHN	H-BERM	Totals	Commission Accuracy	90% Conf. Interval	
																							-	+
	F-COTW	**7**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	100%	100%	93%
	W-WTSB	0	**8**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	100%	100%	94%
	W-SELM	0	0	**4**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	80%	100%	41%
	W-GUMB	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100%	100%	50%
	S-CHPM	0	0	0	0	**6**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	100%	100%	92%
	S-SMSU	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	0	0	0	0	0	2	100%	100%	75%
	S-BLWL	0	0	0	0	1	0	**2**	0	1	0	0	0	0	0	0	0	0	0	0	4	50%	100%	0
	S-SSAG	0	0	0	0	0	1	0	**3**	0	0	0	0	0	1	0	0	0	0	0	5	60%	100%	14%
	S-INDG	0	0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	1	100%	100%	50%
	H-SAND	0	0	0	0	0	0	0	1	0	**1**	0	0	0	0	0	0	0	0	0	2	50%	100%	0
	H-BIGB	0	0	0	0	0	0	0	0	0	0	**13**	0	0	0	0	1	0	0	0	14	93%	100%	78%
	H-LITB	0	0	0	0	0	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0	11	100%	100%	95%
	H-WTWG	0	0	0	0	0	0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	4	100%	100%	88%
	H-BLGR	0	0	0	0	0	0	0	0	0	0	0	3	0	**1**	0	1	0	0	0	5	20%	59%	0
	H-SUMP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	1	0	0	2	50%	100%	0
	H-CEAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**	0	0	0	13	100%	100%	96%
	H-SWGR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**6**	1	0	7	86%	100%	57%
	H-JOHN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**	0	4	100%	100%	88%
	H-BERM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**	4	100%	100%	88%
	Totals	7	8	4	1	7	3	2	4	2	1	13	14	4	2	1	15	7	6	4				
Producer' Error	Omission Accuracy	100%	100%	100%	100%	86%	67%	100%	75%	50%	100%	100%	79%	100%	50%	100%	87%	86%	67%	100%	**92 Total Correct Points**			
	90% Conf. -	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	**105 Total Points**			
	Level +	93%	94%	88%	50%	57%	5%	75%	27%	0	50%	96%	57%	88%	0	50%	69%	57%	27%	88%				
	Overall Total Accuracy = 88% **Overall Kappa Index = 87%** **Overall 90% Upper and Lower Confidence Interval = 81%** and **92%**																							

Discussion

Washita Battlefield National Historic Site is truly a special place that preserves an important landscape commemorating a tragic battle between the United States and Native American Indians. Entrusted to the National Park Service, this site allows visitors to witness the scene of the battle and relive the tragic events that unfolded here almost a 150 years ago. Due to the recent protection of this site, large areas still contain pockets of non-native and introduced plants reminiscent of the past agricultural and cultural activities. These are intermixed with remnants of the native plant communities along the Washita River corridor and on the restored uplands. The resulting fragmentation made it very challenging to both classify and map the vegetation into meaningful context for all levels of interest (local, regional, and national). However, due to the small size of the park and the accessibility afforded to the sampling and verifying efforts a highly accurate classification and map was completed. Even though the accuracy is high there are still some areas were improvements can be made, which are summarized below.

Field Survey

The vegetation data presented in this project should be used as a "baseline" to build upon. New survey work, properly focused would greatly improve both the classification and mapping efforts. Using the accuracy assessment as a guide, map classes with lower accuracy could be further surveyed in the field creating more accurate delineations. While it may appear that there are a large number of associations and alliances described for this small study area, some of the associations/alliances were either only minimally sampled or not sampled at all due to access constraints. It is recommended that these types should receive additional survey work to further define their classification. For example some of the herbaceous types should be examined throughout the growing year to document both the cool and warm season species to refine their composition. Also obtaining access onto neighboring private lands would allow new plot samples to be acquired increasing the confidence in these types, thereby strengthening the classification.

NVC Classification

Along with access onto private lands the other main classification challenge at WABA is keeping up with the rapid changes to plant life caused by agricultural manipulation and anthropogenic disturbance. Changes include tree removal, planting of new grasses, wild fires, and flooding. At all times, but especially after these events, new data should be collected to reflect these changes. For example as the park continues to restore its prairie, more areas in the park may need to be re-classified from weedy types to natural associations (such as Big Bluestem – Indiangrass community type) to better reflect the species that have been seeded. Overall, additional specialized and targeted data collection in these areas would help to document any changes and would greatly increase our understanding of these types in general.

Digital Imagery and Interpretation

Using the existing NAIP imagery as the basemap for this project was based on cost savings. Although the imagery proved adequate it was not acquired by the USDA for vegetation mapping. In the future it may be beneficial to purchase new orthophotos or aerial photos exclusively for mapping the vegetation at WABA. New photography would allow the timing to better match the

phenology of the vegetation and due to the small size of the park, a finer scale (such as 1:6,000) could be acquired allowing for more precise delineations.

Inherent to all vegetation mapping projects is the need to produce both a consistent vegetation classification and a comprehensive set of map units. Typically the systems are very similar, but when using a national classification such as the NVC there is usually not a strict one-to-one correspondence. Nonconformity is due to the remote sensing nature of the interpretation and its ability to delineate map units based on complex photo signatures. Subtle vegetation characteristics that can be seen on the ground are not necessarily the same as those apparent on the imagery. Canopy closure, shadows, and the timing of the imagery acquisition can all impact the vegetation signatures. At WABA these issues can be offset not only by acquiring new imagery but also by conducting more map verification. Increasing the amount of time and money budgeted for verification of the map would greatly improve the accuracy and level of detail. Similarly, this work should only be viewed as an initial mapping effort that needs to be refined and periodically updated. Field checking the existing map by qualified park or contract staff on the ground and incorporating these changes into new versions would keep the product current over the years.

Accuracy Assessment

An important and necessary aspect of this project is the accuracy assessment. By collecting independent ground data the usefulness of the vegetation map is determined. As such, users of this product should remember that the GIS mapping and classification portions of the project were performed separately from both the plot and AA field data collection. These three divisions in work created some challenges related to communication among all the teams, including 1) adequately conveying changes to the classification based on revising the preliminary associations as recorded in the field into the NVC by NatureServe, 2) mapping some types less than the one-quarter acre minimum mapping unit, 3) mapping new associations/alliances found in the environs but not found in the park and 4) generally providing enough instruction and interaction to the field crews to explain how these changes would effect the AA.

Specifically at WABA the new associations and alliances occurring primarily in the environs and as small patches inside the park should have been included and marked as such in the field key. Field key notes would have indicated to the crews that they would probably not encounter some types in the AA and if they did these would be new and should be sampled with a full plot and not an AA point. Confusion in the classification resulted from the ability of the mappers to see plant communities on the imagery that occurred outside of the park or as small stands within larger units within the park. Since these communities were not known to the AA crews no plot sampling was conducted in these types.

Similar to the issues stated above, the underlying issue to all of the complications was an overall lack of interaction and communication between the field and GIS teams likely resulting from scale-related and perspective issues. As mentioned previously, looking at vegetation from an overhead perspective varies greatly from seeing it on the ground. Because of the extensive field exposure to the vegetation at WABA, the field team was very knowledgeable about the parks' habitats. Onsite knowledge included a thorough understanding of when one association changed to another either due to succession or an ecotone. Since the mapping team was tasked to provide a map of the existing vegetation the delineation on the map did not always match what the field

team viewed as the break between plant associations. Similarly small stands of vegetation that were accurately mapped on the aerial photography were seen by the field crews as actually being inclusions in larger units and vice versa. This discrepancy could also be explained as stemming from the fundamental difference between deriving vegetation from imagery signatures versus ecological or field experience. In the future it would be helpful if more communication could occur between all teams involved. Communication would at a minimum include multiple field visits by all teams at the same time and possibly reducing the number of researchers by finding participants that could conduct multiple tasks.

Future Recommendations

In summary, this project represents the best efforts put forth by a multi-disciplined team over a relatively short period in time. In order to create the best possible "long-term" vegetation classification for WABA and the most accurate and detailed GIS layer, this project should be viewed as a place to start rather than an end product. In other words, present and future NPS staff should be encouraged to scrutinize this project, building from its strengths and bolstering its weaknesses. By keeping in mind that this project was only a snapshot in time, future efforts can help complete our understanding of the vegetation in and around WABA and how it changes. It is the hope of the producers that the products presented here will help focus and direct future efforts. The following recommendations are summarized below.

1. The diversity of plant species and dynamic nature of the park warrants periodic **field surveys** by experienced ecologists. Further the inaccessibility of the private lands in the environs should be addressed by seeking permission and sampling the vegetation. In this way new plant associations could be discovered and existing types could be updated.

2. Remote sensing does not replace on-the-ground knowledge provided by GPS linked plots, observations and ground verification. Time and funding limitations curtailed the amount of map **ground-truthing** performed. As opportunities arise, maps should be examined in the field by experienced crews. Also GPS data and other GIS layers should be used to improve and update the spatial data. This map product should not be viewed as static but should change with more current and accurate information.

3. To better understand the limitations of the map, the **accuracy assessment** data presented in Table 7 should be thoroughly reviewed by the park staff. Map classes with low accuracy should be examined to see if they could be improved with future studies using ground-truthing or other remote-sensing formats (i.e. color infrared imagery, hyperspectral, etc). Also, landscape modeling may help to tease out the location of specific types based on specific habitat information. Finally for some applications it may make sense to combine map classes into higher units, such as alliances or ecological systems to improve accuracy**.**

4. For monitoring purposes, **change over time** could be addressed by similar remote sensing projects. New aerial photos or NAIP imagery acquired every year could be used in regular intervals to capture changes. This new imagery could be used to create up-to-date vegetation layers that could be used to compare changes in both specific vegetation stands and across the entire park.

5. In the future, resource management personnel could link the habitat for **species of concern** to specific associations and map units. These map units could then be used to help locate potential sites of endangered or threatened species in the field or identify areas for non-native plant removal or treatment.

Research Opportunities

Having an accurate and current vegetation classification and map presents many new and exciting research opportunities. Research could include expanding or linking the GIS layer to derive other information such as fire models, habitat monitoring locations, guides for rare plant surveys, and inventorying areas that likely contain exotic or invasive species. The map could also be enhanced by overlaying other existing GIS layers such as geology, hydrology, elevation, and soils. In this manner complex interactions between these layers could be examined and yield important information about growth rates, regeneration after disturbance, biomass distribution, and stream morphology. Finally, through innovative analyses the vegetation layer could possibly be used as a springboard for other ecological studies such as examining how the vegetation interacts with soil chemistry, pollution, archeological sites, weather patterns, etc.

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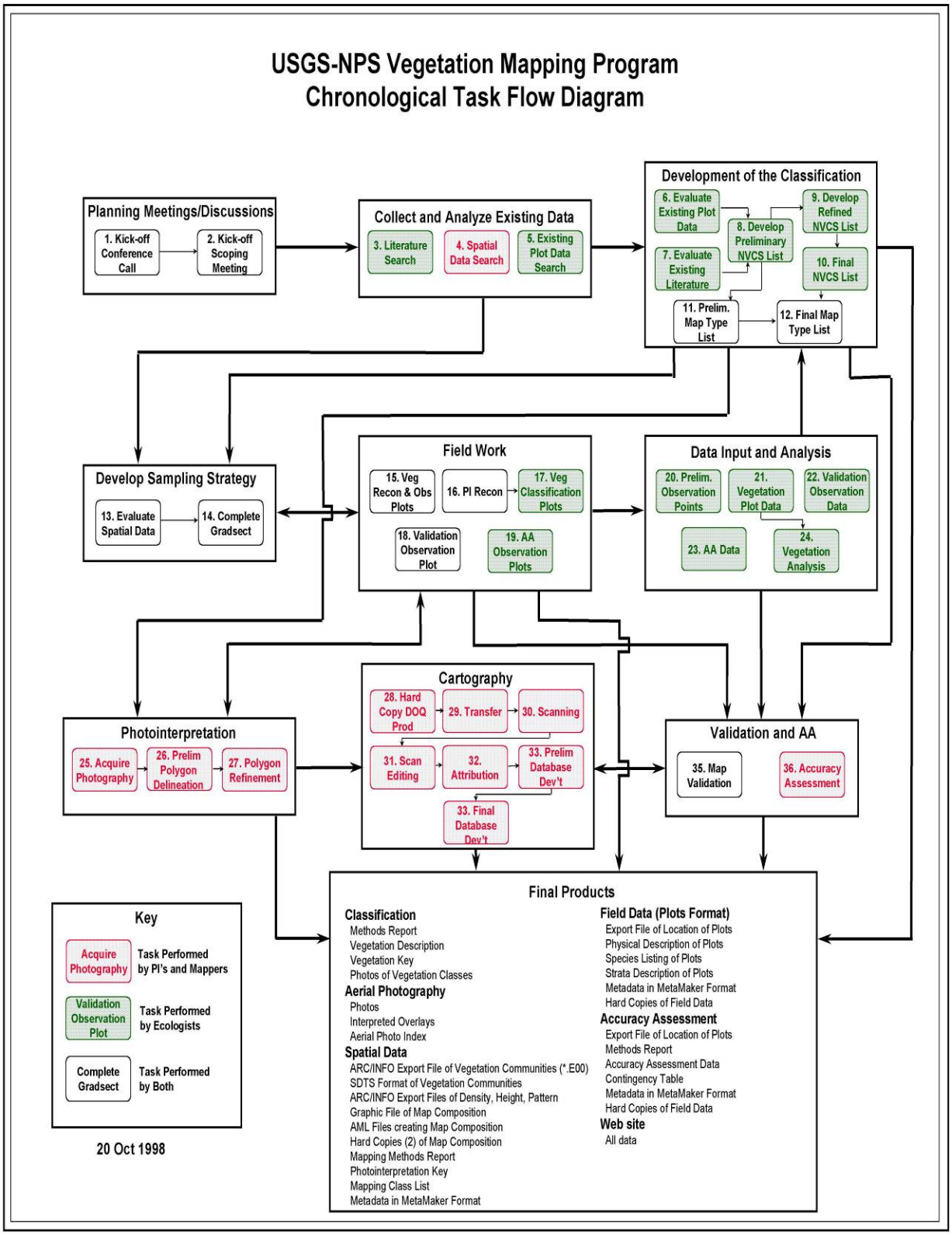
APPENDIX A: Components and Flow Diagram of the Vegetation Classification and Mapping Program

(Developed by Tom Owens USGS – BRD)



APPENDIX B: Field Data Forms and Instructions

General instructions for filling out fields in the PLOT SURVEY FORM

IDENTIFIERS/LOCATORS

Plot Code
Code indicating the specific plot within the vegetation polygon.

Surveyors
Names of surveyors, with principal surveyor listed first.

Date
Date the survey was taken; year, month, day.

BPU Code
The biophysical unit identified.

Provisional Community Name
Using the provisional classification of the Park that was provided, assign the name of the vegetation type which most closely resembles this type. Enter the finest level of the classification possible. If it's a new type, name it based on the two or three most dominant species in the plot.

Quad Name
Appropriate name/scale from survey map used; use 7.5-minute quadrangle if possible.

Park Site Name
Provisional name assigned by field worker that describes where the data were collected. It should represent an identifiable feature on a topographic map.

GPS Rover File
Record the number of the file from the GPS unit.

Field UTM X
Use GPS; do not estimate. If you can't get a GPS reading, estimate coordinates from a topo map and note on the form that this method was used.

Field UTM Y
Use GPS; do not estimate. If you can't get a GPS reading, estimate coordinates from a topo map and note on the form that this method was used.

Error
Record this off the GPS unit.

Plot Length and Plot Width
Enter width and length dimensions for square or rectangular plots. Choose the appropriate plot size based on the following:

Vegetation Class	Standard Plot Dimensions	PLOT AREA
Forest	20 m x 20 m	400 m^2
Woodland	20 m x 20 m	400 m^2
Shrubland	20 m x 20 m	400 m^2
Dwarf-shrubland (heath)	10 m x 10 m	100 m^2
Herbaceous	10 m x 10 m	100 m^2
Nonvascular	5 m x 5 m	25 m^2

Photo numbers
If photos of the plot have been taken at the time of sampling, indicate their numbers from the ones the camera assigns.

Plot Permanent
Note if the plot has been permanently marked.

Plot Representativeness
Does this plot represent the full variability of the polygon? If not, were additional plots taken? Note: we distinguish in this section the plot's ability to represent the stand or polygon you are sampling as one component, and the ability of this sample to represent the range of variability of the association in the entire mapping area. The former comment may be ascertained by reconnaissance of the stand. The latter comment comes only after some familiarity with the vegetation type throughout the mapping area and may be left blank if you have no opinion at this time.

ENVIRONMENTAL DESCRIPTION

Elevation
Elevation of the plot obtained from the GPS

Slope
Measure the slope in percent using a clinometer.

Aspect
Measure the aspect using a compass (be sure compass is set to correct for the magnetic declination).

Topographic Position
Choose one:

INTERFLUVE (crest, summit, ridge). Linear top of ridge, hill, or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways.

SHOULDER (shoulder slope, upper slope, convex creep slope). Geomorphic component that forms the uppermost inclined surface at the top of a slope. Includes the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.

BACKSLOPE. Subset of midslopes that are steep, linear, and may include cliff segments (fall faces).

FOOTSLOPE (lower slope, foot slope, colluvial footslope). Inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between backslope, and toeslope.

TOESLOPE (alluvial toeslope). Outermost gently inclined surface at base of a slope. In profile, commonly gentle and linear and characterized by alluvial deposition.

TERRACE Valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

CHANNEL (narrow valley bottom, gully arroyo). Bed of single or braided watercourse commonly barren of vegetation and formed of modern alluvium.

BASIN FLOOR (depression). Nearly level to gently sloping, bottom surface of a basin.

Describe Topographic Position (Optional)
Give more details here, if needed.

Cowardin System
Indicate "upland" if the system is not a wetland. If the system is a wetland, check off the name of the USFWS system which best describes its hydrology and landform.

- Riverine: Below the high water mark on a moving water system (a creek bed). A community of *Eleocharis* on a sand bar would be in this category.
- Palustrine: In the riparian zone. Plants regularly have wet roots through much of the summer. A community of willows and sedges would be in this category.
- Lacustrine: Below the high water mark of a lake. The marshy stuff on the edge of a lake would be in this category.

Assess the hydrologic regime of the plot using the descriptions below (adapted from Cowardin et al. 1979).

PERMANENTLY FLOODED - Water covers the land surface at all times of the year in all years. Equivalent to Cowardin's "permanently flooded."

SEMIPERMANENTLY FLOODED - Surface water persists throughout growing season in most years except during periods of drought. Land surface is normally saturated when water level drops below soil surface. Includes Cowardin's Intermittently Exposed and Semipermanently Flooded modifiers.

SEASONALLY FLOODED - Surface water is present for extended periods during the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is very variable, extending from saturated to a water table well below the ground surface. Includes Cowardin's Seasonal, Seasonal-Saturated, and Seasonal-Well Drained modifiers.

SATURATED - Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season. Equivalent to Cowardin's Saturated modifier.

TEMPORARILY FLOODED - Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Often characterizes flood-plain wetlands. Equivalent to Cowardin's Temporary modifier.

INTERMITTENTLY FLOODED - Substrate is usually exposed, but surface water can be present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and is dependent upon highly localized rain storms. This modifier was developed for use in the arid West for water regimes of Playa lakes, intermittent streams, and dry washes but can be used in other parts of the U.S. where

appropriate. This modifier can be applied to both wetland and non-wetland situations. Equivalent to Cowardin's Intermittently Flooded modifier.

UNKNOWN - The water regime of the area is not known. The unit is simply described as a non-tidal wetland.

Unvegetated Surface
Estimate the approximate percentage of the *total* surface area covered by each category.

Soil Texture
Using the key below, assess average soil texture.

<u>Simplified Key to Soil Texture</u>
Soil does not remain in a ball when squeezed.....sand
Soil remains in a ball when squeezed.....2

Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you can push up over your finger.
2. Soil makes no ribbon.....……..……loamy sand
2. Soil makes a ribbon (may be very short).....3

3. Ribbon extends less than 1 inch before breaking.....4
Add excess water to small amount of soil:

4. Soil feels smooth.....silt loam
4. Soil feels at least slightly gritty……...…….…5
Squeeze a moistened ball:
5. Cast is formed which can be handled CAREFULLY without breaking…..……. sandy loam
5. Cast is formed which can be handled FREELY without breaking…… ……loam

3. Ribbon extends 1 inch or more before breaking.....6

5. Soil makes a ribbon that breaks when 1 to 2 inches long; cracks if bent into a ring.....7

Add excess water to small amount of soil:
7. Soil feels at least slightly gritty…….....clay loam
7. Soil feels smooth.....silt

6. Soil makes a ribbon 2+ inches long; does NOT crack when bent into a ring…… 8
Add excess water to a small amount of soil:

8. Soil feels at least slightly gritty.....……..clay
8. Soil feels smooth.....silty clay

HANDBOOK ON SOILS

In the field, soil texture is determined by the feel of a moist soil when it is rubbed between the thumb and fingers. Since sand particles feel gritty, silt particles have a smooth velvety feel and clay is both sticky and plastic, an estimate of the relative proportions of the separates may be made. This procedure, of course, will not give the exact percentage *o*f sand, silt, and clay, but, with a little practice on samples of known composition, the relative proportions of the individual separates can be closely estimated. Practice with known samples is the only way to acquire this facility.

The outstanding physical characteristics of the main textural grades as determined by the feel of the soil are described below.

1. Sandy Soil. A sandy soil is loose and single grained. The individual grains can be seen readily or felt. Squeezed in the hand when dry, it will fall apart when pressure is released. Squeezed when moist, it will form a cast, but will crumble when touched.

2. Sandy Loam Soil. A sandy loam soil contains much sand, but has enough silt and clay to make it somewhat coherent. Individual sand grains can be easily seen and felt. Squeezed when dry, it will form a cast which will readily fall apart; but if squeezed when moist a cast can be formed which will bear careful handling without breaking.

3. Loam Soil. A loam soil is about an equal mixture of the sand and silt with the clay content being between 7 and 27 percent. A loam is mellow with a somewhat sandy feel, yet fairly smooth and slightly plastic. Squeezed when moist, it will form a cast which can be handled freely without breaking.

4. Silt Loam Soil. A silt loam soil, when dry, may appear cloddy, but lumps are readily broken, and when pulverized, it feels soft and floury. When wet, the soil readily runs together. Either dry or moist, it will form casts which can be handled freely without breaking, but when moistened and extruded between the thumb and fingers, it will not form a ribbon, but will give a broken appearance.

5. Clay Loam Soil. A clay loam soil is fine-textured and usually breaks into clods or lumps that are hard when dry. When moist and extruded between the thumb and fingers, it will form a thin "ribbon" which will break readily, barely sustaining its own weight. The moist soil is plastic and will form a cast that will bear much handling. When kneaded in the hand, it does not crumble readily, but tends to work into a heavy, compact mass.

6. Clay Soil. A clay soil is fine-textured and usually forms very hard lumps or clods when dry and is plastic and sticky when wet. When the moist soil is ribboned out between the thumb and fingers, it will form a long flexible strip. A clay soil leaves a "slick' surface on the thumb and fingers when rubbed together and tends to hold the thumb and fingers together due to the stickiness of the clay.

The characteristics described above are suggestive only, and will only apply to a group of similar soils. The characteristics of clay vary with the kind of clay mineral. For this reason, textural

grades may exhibit different properties from region to region. For instance, clays of the montmorillonite group are very sticky and plastic; those of the oxide group are plastic and waxy with relatively little stickiness.

The preceding discussion has been directed to those soil particles whose diameters are less than 2 millimeters--the sands, silts, and clays. Soils may also contain larger sized particles that may be collectively called coarse fragments. These large particles may on occasion exceed the smaller soil particles in volume.

Soil Drainage

The soil drainage classes are defined in terms of (1) actual moisture content (in excess of field moisture capacity) and (2) the extent of the period during which excess water is present in the plant-root zone. It is recognized that permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot generally be used as criteria of moisture status. It is further recognized that soil profile morphology, for example mottling, normally, but not always, reflects soil moisture status. Although soil morphology may be a valuable field indication of moisture status, it should not be the overriding criterion. Soil drainage classes cannot be based solely on the presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

> WELL DRAINED - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year.
>
> MODERATELY WELL DRAINED - The soil moisture content is in excess of field capacity for a small but significant period of the year.
>
> POORLY DRAINED - The soil moisture content is in excess of field capacity in all horizons for a large part of the year.

VEGETATION DESCRIPTION

Leaf Phenology
Select the value which best describes the leaf phenology of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

> EVERGREEN - Greater than 75% of the total woody cover is never without green foliage.
>
> COLD DECIDUOUS - Greater than 75% of the total woody cover sheds its foliage in connection with an unfavorable season mainly characterized by winter frost.

MIXED: EVERGREEN & COLD DECIDUOUS - Evergreen and deciduous species generally contribute 25-75% of the total woody cover. Evergreen and cold-deciduous species are mixed.

PERENNIAL - Herbaceous vegetation composed of more than 50% perennial species.

ANNUAL - Herbaceous vegetation composed of more than 50% annual species.

Leaf Type
Select the value which best describes the leaf form of the dominant stratum. The dominant stratum is the uppermost stratum that contains at least 10% cover.

BROAD-LEAVED - Woody vegetation primarily broad-leaved (generally contributes greater than 50 percent of the total woody cover).

NEEDLE-LEAVED - Woody vegetation primarily needle-leaved (generally contributes greater than 50 percent cover).

GRAMINOID - Herbaceous vegetation composed of more than 50 percent graminoid/stipe leaf species.

FORB (BROAD-LEAF-HERBACEOUS) - Herbaceous vegetation composed of more than 50% broad-leaf forb species.

PTERIDOPHYTE - Herbaceous vegetation composed of more than 50 percent species with frond or frond-like leaves. (Ferns)

Physiognomic Class
Choose one:
Forest: Trees with their crowns overlapping (generally forming 60-100% cover).

Woodland: Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover.

Shrubland: Shrubs generally greater than 2.5 feet tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover.

Dwarf-Shrubland: Low-growing shrubs usually under 2.5 feet tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover.

Herbaceous: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover.

Nonvascular: Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover.

Sparse Vegetation: Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).

Strata, Height Class, Cover Class, Diagnostic Species
Visually divide the community into vegetation layers (strata). Indicate the average height class of the stratum in the first column, using the Height Scale on the form. Enter the average percent cover class of the whole stratum in the second column, using the Cover Scale on the form. Height and Cover classes are also listed below.

Trees are defined as single-stemmed woody plants, generally 15 feet in height or greater at maturity and under optimal growing conditions. Shrubs are defined as multiple-stemmed woody plants generally less than 15 feet in height at maturity and under optimal growing conditions.

List the dominant species in each stratum.

Animal Use Evidence
Comment on any evidence of wildlife (i.e., tracks, scat, gopher or prairie dog mounds, etc.). Notes on domestic animals should be made in the field below.

Natural and Anthropogenic Disturbance
Comment on any evidence of natural or anthropogenic disturbance and specify the source.

Environmental Comments
Enter any additional noteworthy comments on the environmental setting. This field can be used to describe site history such as fire events (date since last fire or evidence of severity) as well as other disturbance or reproduction factors

Other Comments
Any miscellaneous comments.

Species/Strata/Percent Cover Table

The main use of the strata information is to categorize the plots by life form, in order to subset the data into forest, woodland, shrublands, and herbaceous plots for analysis. It is imperative that things be called the same throughout the data set.

Starting with the uppermost stratum, list all the species present and their cover class using the scale provided below. If a species is in the tree layer (single-stemmed woody plants, generally 15 feet in height or greater at maturity), list whether it is T1 (emergent tree), T2 (tree canopy), or T3 (tree sub-canopy). If a species is in the shrub layer, note if S1 (tall shrub), or S2 (short shrub), or S3 (dwarf shrub). If in the ground layer, note if H (herbaceous), N (nonvascular). Some species will be in more than one layer. For example, Cottonwoods might have one or two especially tall specimens, which would be in the T1 (emergent tree) layer. Then the majority of the mature trees would be in T2 (tree canopy). The saplings that are coming up in the understory would be in the T3.

Seedlings are defined as trees less than "breast height" or less than 4.5 feet tall. Seedlings between knee height and breast height should be labeled as being in the short shrub layer (S2), and those below knee height should be labeled as being in the dwarf shrub layer (S3).

Cover Scale for Species Percent Cover

Use the cover scales provided on the forms.

NATIONAL PARK VEGETATION MAPPING PROGRAM: PLOT SURVEY FORM

IDENTIFIERS/LOCATORS

Plot Code_____ Polygon Code_____

Provisional Community Name_____

State ___ Park Name_____ Park Site Name_____

Quad Name_____ Quad Code_____

GPS file name_____ Field UTM X___ ___ ___ ___ ___ ___ m E Field UTM Y___ ___ ___ ___ ___ ___ ___ m N

Error +/-_____ m

please do not complete the following information when in the field

Corrected UTM X___ ___ ___ ___ ___ ___ m E Corrected UTM Y___ ___ ___ ___ ___ ___ ___ m N UTM Zone_____

Survey Date_____ Surveyors_____

Directions to Plot

Plot length_____ Plot width_____ Plot Photos (y/n) ___ Roll Number _____ Frame Number _____ Plot Permanent (y/n) ___

Plot representativeness

ENVIRONMENTAL DESCRIPTION

Elevation _____ Slope _____ Aspect_____

Topographic Position

Landform

Surficial Geology

Cowardian System ___Upland ___Riverine ___Palustrine ___Lacustrine	Non-Tidal ___Permanently Flooded ___Semipermanetly Flooded ___Seasonally/Temporarily Flooded	___Saturated ___Seasonally Flooded/Saturated ___Intermittently Flooded	

Environmental Comments:	Soil Taxon/Description
	Unvegetated Surface: *(please use the cover scale on next page)* ___ Bedrock ___ Litter, duff ___ Wood (> 1 cm) ___ Large rocks (cobbles, boulders > 10 cm) ___ Small rocks (gravel, 0.2-10 cm) ___ Sand (0.1-2 mm) ___ Bare soil ___ Other:_____
Soil Texture ___ sand ___ loamy sand ___ sandy loam ___ loam ___ silt loam ___ silt ___ clay loam ___ silty clay ___ clay ___ peat ___ muck	Soil Drainage ___ Rapidly drained ___ Well drained ___ Moderately well drained ___ Somewhat poorly drained ___ Poorly drained ___ Very poorly drained

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Cover Scale for Strata & Unvegetated Surface		Height Scale for Strata	
Trees and Shrubs		___Forest				
___Evergreen	___Broad-leaved	___Woodland	01	5%	01	<0.5 m
___Cold-deciduous	___Needle-leaved	___Shrubland	02	10%	02	0.5-1m
___Drought-deciduous	___Microphyllous	___Dwarf Shrubland	03	20%	03	1-2 m
___Mixed evergreen - cold-deciduous	___Graminoid	___Herbaceous	04	30%	04	2-5 m
___Mixed evergreen - drought-deciduous	___Forb	___Nonvascular	05	40%	05	5-10 m
	___Pteridophyte	___Sparsely Vegetated	06	50%	06	10-15 m
Herbs			07	60%	07	15-20 m
___Annual			08	70%	08	20-35 m
___Perennial			09	80%	09	35 - 50 m
			10	90%	10	>50 m
			11	100%		

Strata	Height Class	Cover Class	Diagnostic species (if known)
T1 Emergent			
T2 Canopy			
T3 Sub-canopy			
S1 Tall shrub			
S2 Short Shrub			
H Herbaceous			
N Non-vascular			
V Vine/liana			
E Epiphyte			

please see above table for height and cover scales

Animal Use Evidence

Natural and Anthropogenic Disturbance Comments

Other Comments

Plot Code_____

Species/percent cover: Starting with the uppermost stratum, list all species with % cover for each species in the stratum. For each tree species estimate seedling, sapling, mature and total cover indicating stratum. Also for forests and woodlands, on a separate page or line below each tree species, list the DBH of all trees above 5 cm diameter. Separate measurements with a comma (note if measurements are from multi-stemmed tree). Put an asterisk next to any species that are known diagnostics for a particular community in the classification. **Also list species outside the plot at the end of the table or designate with a 0 in Cover Class column.**

Stratum	Species Name	Cover Class	Stratum	Species Name	Cover Class	Stratum	Species Name	Cover Class

Cover Class Scale

T = >0-1%	5 = >45-55%
P = >1-5%	6 = >55-65%
1 = >5-15%	7 = >65-75%
2 = >15-25%	8 = >75-85%
3 = >25-35%	9 = >85-95%
4 = >35-45%	10 = >95%

Tree D.B.H Form

Plot Code:____________________________Units in cm or inches (circle one)

Record tree diameter over 5 cm at 4.5 feet (1.37 m) height for species that contribute to tree canopy.

Separate measurements of multi-stemmed trees with commas. Can estimate by 5 cm dia. classes

Species	D.B.H.(s) for multi-stems trees

Species	D.B.H.(s) for multi-stems trees

NATIONAL PARK VEGETATION MAPPING PROGRAM: OBSERVATION POINT FORM (1997)

IDENTIFIERS/LOCATORS

Plot Code_____ Polygon Code_____

Provisional Community Name_____

State ___ Park Name _____ Park Site Name _____

Quad Name_____ Quad Code_____

GPS file name_____ Field UTM X___ ___ ___ ___ ___ ___ m E Field UTM Y___ ___ ___ ___ ___ ___ ___ m N

please do not complete the following information when in the field
Corrected UTM X___ ___ ___ ___ ___ ___ m E Corrected UTM Y___ ___ ___ ___ ___ ___ ___ m N UTM Zone_____

Survey Date_____ Surveyors_____

ENVIRONMENTAL DESCRIPTION

Elevation _____ Slope _____ Aspect_____

Topographic Position

Landform

Cowardian System	Hydrologic Regime		Salinity Modifiers
___Upland	Non-Tidal		___Saltwater
___Riverine	___Permanently Flooded	___Saturated	___Brackish
___Palustrine	___Semipermanetly Flooded	___Temporarily Flooded/Saturated	___Freshwater
___Lacustrine	___Seasonally Flooded	___Intermittently Flooded	

Environmental Comments:	Unvegetated Surface: (please use the cover scale below)
	___ Bedrock ___ Litter, duff ___ Wood (> 1 cm)
	___ Large rocks (cobbles, boulders > 10 cm)
	___ Small rocks (gravel, 0.2-10 cm)
	___ Sand (0.1-2 mm) ___ Bare soil
	___ Other:_____

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Cover Scale for Strata & Unvegetated Surface		Height Scale for Strata	
Trees and Shrubs		___Forest				
___Evergreen	___Broad-leaved	___Woodland	01	5%	01	<0.5 m
___Cold-deciduous	___Needle-leaved	___Shrubland	02	10%	02	0.5-1m
___Drought-deciduous	___Mixed broad-leaved/Needle leaved	___Dwarf Shrubland	03	20%	03	1-2 m
___Mixed evergreen - cold-deciduous	___Microphyllous	___Herbaceous	04	30%	04	2-5 m
___Mixed evergreen - drought-deciduous	___Graminoid	___Nonvascular	05	40%	05	5-10 m
	___Forb	___Sparsely Vegetated	06	50%	06	10-15 m
Herbs	___Pteridophyte		07	60%	07	15-20 m
___Annual			08	70%	08	20-35 m
___Perennial			09	80%	09	35 - 50 m
			10	90%	10	>50 m
			11	100%		

Strata	Height	Cover Class	Dominant species (mark any known diagnostic species with a *)	Cover Class
T1 Emergent	_____	_____	_____	
T2 Canopy	_____	_____	_____	
T3 Sub-canopy	_____	_____	_____	
S1 Tall shrub	_____	_____	_____	
S2 Short Shrub	_____	_____	_____	
S3 Dwarf-shrub H Herbaceous	_____	_____	_____	
N Non-vascular	_____	_____	_____	
V Vine/liana	_____	_____	_____	
E Epiphyte	_____	_____	_____	

please see the table on the previous page for height and cover scales for strata

Other Comments

Cover Scale for Species
01 <1%
02 1-5%
03 5-25%
04 25-50%
05 50-75%
06 75-100%

ACCURACY ASSESSMENT POINT FORM

IDENTIFIERS/LOCATORS

Field Point Code _____ Database Point Code _____

State __ Park Name _____ Park Site Name _____

Quad Name_____ QuadCode_____

Primary Name Veg Assoc: _____

Secondary Name Veg Assoc:_____

Other Veg Assoc within 50 m _____

Classification Comments:

GPS file name_____ Field UTM X___ ___ ___ ___ ___ ___ m E Field UTM Y___ ___ ___ ___ ___ ___ ___ m N

GPS Error _____ m

please do not complete the following information when in the field

Corrected UTM X___ ___ ___ ___ ___ ___ m E Corrected UTM Y___ ___ ___ ___ ___ ___ ___ m N UTM Zone____

Survey Date_____
Surveyors_____

ENVIRONMENTAL DESCRIPTION

Elevation _____ Slope _____Aspect_____

Topographic Position

Landform

Environmental Comments (including hydrology):	Unvegetated Surface: *(please use the cover scale below)* ___ Bedrock ___ Litter, duff ___ Wood (> 1 cm) ___ Large rocks (cobbles, boulders > 10 cm) ___ Small rocks (gravel, 0.2-10 cm) ___ Sand (0.1-2 mm) ___ Bare soil ___ Other:_____

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	HEIGHT (M)	COVER SCALE
Trees and Shrubs	___Broad-leaved	___Forest	01 -<0.5	T - <1%
___Evergreen	___Needle-leaved	___Woodland	02 - 0.5-1	01 - 1-5%
___Cold-deciduous	___Mixed broad-lvd/Needle-lvd	___Shrubland	03 - 1-2	02 - 6-15%
___Drought-deciduous	___Microphyllous	___Dwarf-shrubland	04 - 2-5	03 - 16-25%
___Mixed evergreen - cold-deciduous	___Graminoid	___Herbaceous	05 - 5-10	04 - 26-35%
___Mixed everg. - drought-deciduous	___Forb	___Nonvascular	06 - 10-15	05 - 36-45%
Herbs	___Pteridophyte	___Sparsely Vegetated	07 - 15-20	06 - 46-55%
___Annual			08 - 20-35	07 - 56-65%
___Perennial			09 - 35-50	08 - 65-75%
			10 ->50	09 - 76-85%
				10 - 86-95%
				11- 96-100%

Strata	Height Class	Cover Class	Dominant species (mark any known diagnostic species with a *)	Cover Class
T1 Emergent	____	____		
T2 Canopy	____	____		
T3 Sub-canopy	____	____		
S1 Tall shrub	____	____		
S2 Short Shrub	____	____		
S3 Dwarf-shrub	____	____		
H Herbaceous	____	____		
N Non-vascular	____	____		
V Vine/liana	____	____		
E Epiphyte	____	____		

APPENDIX C: Dichotomous Key to WABA Plant Associations

Key to Vegetation types at WABA (Developed By Roger Sanders, Botanical Research Institute of Texas, May 2006)

1. Trees forming ≥ 20% canopy, or if less (rarely), then canopy and subcanopy (everything > 5 m tall) total ≥ 30% cover: forests and woodlands..... 2

1. Tree canopy ≤ 10%, or if slightly more, then canopy and subcanopy together total < 30% (these layers usually total < 10%): non-forested vegetation.....3

2. Vegetation on floor of floodplain or old channels

***Populus deltoides – Ulmus americana – Celtis laevigata* Forest**

2. Vegetation on slopes of old high terraces or upland slopes above the floor of the floodplain

***Sapindus saponaria* Woodland**

3. Shrubs dominant ***Prunus angustifolia* Shrubland ALLIANCE**

3. Herbs dominant..... 4

4. Vegetation in saturated silt and sand of riverine depositional bars and basal channel banks

***Schoenoplectus pungens – Paspalum distichum* Herbaceous Vegetation**

4. Vegetation in intermittently flooded valley floors or non-flooded uplands 5

5. Spring annual grasses and summer forbs dominant..... 6

5. Late season grasses dominant 7

6. Vegetation of floodplain, on level valley floor, in old channels, terrace depressions, or bank of main channel on silt, loamy sand , or recent silty-sand alluvium; usually dominated by *Ambrosia psilostachya*, *Ambrosia trifida, Bromus japonicus, Bromus tectorum, Conyza canadensis*, or *Iva annua*, but not mixtures of *Heterotheca subaxillaris*, *Croptilon hookerianum, Eriogonum annuum,* and *Mentzelia nuda.*

***Iva annua – (Xanthium strumarium)* Temporarily Flooded Herbaceous Vegetation**

6. Vegetation of uplands or old raised natural deep sand natural levees or old sand dunes in floodplain; usually dominated by *Ambrosia psilostachya*, *Bromus japonicus, Grindelia papposa, Helianthus annuus* and mixtures of *Heterotheca subaxillaris*, *Croptilon hookerianum, Eriogonum annuum,* and *Mentzelia nuda*.

***Bromus tectorum* Semi-Natural Herbaceous ALLIANCE**

7. Vegetation of floodplain, on level valley floor, in old channels, terrace depressions, or bank of main channel on silt, loamy sand, or recent silty-sand alluvium

***Andropogon gerardii – Sorghastrum nutans* Western Great Plains Herbaceous Vegetation**

7. Vegetation of uplands or old raised natural deep sand natural levees or old sand dunes in floodplain 8

8. Vegetation on deep sands or loamy sands; dominated by *Andropogon hallii* and often accompanied by *Schizachyrium scoparium* or *Artemisia filifolia*.

***Andropogon hallii – Calamovilfa gigantea* Herbaceous Vegetation**

8. Vegetation on sandy loam or gravel-adulterated soils; *Andropogon hallii* sometimes present but not dominant. 9

9. Vegetation on gravelly soils modified for railroad grade; dominated by *Pascopyrum smithii*

***Pascopyrum smithii* Herbaceous ALLIANCE**

9. Vegetation on natural sandy loam soils of slopes and ridges 10

10. Vegetation on ridge crests and exposed mounds with shale outcrops; dominated by *Bouteloua gracilis*. ***Bouteloua gracilis – Bouteloua curtipendula* Herbaceous Vegetation**

10. Vegetation on upper, side, and lower slopes, dominated by *Schizachyrium scoparium*, usually with *Bouteloua curtipendula* as an important subdominant. ***Schizachyrium scoparium – Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation**

APPENDIX D: Vegetation Association Descriptions for WABA

NatureServe. 2006. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of December 2006.

U.S. NATIONAL VEGETATION CLASSIFICATION

Washita Battlefield National Historic Site

December 31, 2006

By
NatureServe
1101 West River Parkway Suite 200
Minneapolis, Minnesota 55415

And
NPS - Southern Plains Network Coordinator
P.O. Box 329, 100 Ladybird Lane
Johnson City, TX 78636

This subset of the U.S. National Classification covers vegetation associations and alliances attributed to Washita Battlefield National Historic Site**.** This classification has been developed in consultation with many individuals and agencies and incorporates information from a variety of publications and other classifications. Comments and suggestions regarding the contents of this subset should be directed to Jim Drake, Regional Vegetation Ecologist, 612-331-0729, jim_drake@natureserve.org or Heidi Sosinski, Data Manager, 830-868-7128 ext. 282, heidi_sosinski@nps.gov.

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Citations:
The following citation should be used in any published materials which reference ecological system and/or International Vegetation Classification (IVC hierarchy) and association data: NatureServe. 2006. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of December 2006.

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NatureServe
1101 Wilson Blvd, 15th floor
Arlington, VA 22209

These data are extracted from:
NatureServe. 2006. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of December 2006.

This document may be cited as follows:
NatureServe1 and WABA. 2006. U.S. National Vegetation Classification: Washita Battlefield National Historic Site: Global and Local Descriptions. NatureServe Central Databases. Arlington, VA, NatureServe Midwest Office, Minneapolis, MN and Washita Battlefield National Historic Site, Cheyenne, OK. Data current as of December 2006.

1 NatureServe is an international organization including NatureServe regional offices, a NatureServe central office, U.S. State Natural Heritage Programs, and Conservation Data Centres (CDC) in Canada and Latin America and the Caribbean. Ecologists from the following organizations have contributed the development of the ecological systems classification:

CEGL002090 *Populus deltoides – Ulmus americana – Celtis laevigata* Forest

Translated Name: Eastern Cottonwood – American Elm – Sugarberry Forest
Common Name: Eastern Cottonwood – American Elm – Sugarberry Forest

Ecological System(s): Western Great Plains Floodplain CES303.678
Status: **Circumscription Confidence: 2**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, and chance historical events. This community occurs on silty soils in old stream channels and on the valley floor immediately back of the main natural levees bordering the Washita River. These areas probably have greater water availability than those of the main valley floor. Composition of tree species at any given site is probably largely dependent on chance establishment, especially following damaging floods. Flooding of major proportions does not occur as it once did due to impoundments upstream.

VEGETATION DESCRIPTION

Local Vegetation: This community is dominated by mix of *Populus deltoides, Ulmus americana*, *Celtis laevigata*, and *Salix nigra*, with the exact composition varying from one site to the next. Canopy cover varies from 25-60%. *Ulmus americana* is commonly present in most sites, forming a subcanopy cover of mostly 20–60% except where *Populus deltoides* is so sparse that it form the main canopy. *Salix nigra* occurs as scattered trees, rarely becoming common enough to forms the main canopy. A shrub layer with commonly about 15–30% cover consists mostly of sapling of *Ulmus americana, Celtis laevigata* and *Sapindus saponaria*. A few plants of *Tamarix ramosissima* that were missed by an eradication program still occur. The ground layer has a cover often of about 50% and generally extends to over a meter tall composed of shade tolerant forbs (*Ambrosia trifida, Teucrium canadense*), graminoids (*Elymus* spp., *Muhlenbergia* spp., and *Carex gravida*), trailing or sprouting vines (*Toxicodendron radicans, Cocculus carolina, Cissus trifolia,* and *Parthenocissus quinquefolia*), and tree seedlings.

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Populus deltoides	**Tree canopy**	Broad-leaved deciduous tree	X	X	
Salix nigra	**Tree canopy**	Broad-leaved deciduous tree		X	
Ulmus americana	**Tree (canopy & subcan)**	Broad-leaved deciduous tree	X	X	X
Celtis laevigata	**Tree (canopy & subcan)**	Broad-leaved deciduous tree		X	
Ulmus americana	**Shrub/sapling**	Broad-leaved deciduous tree	X	X	X
Celtis laevigata	**Shrub/sapling**	Broad-leaved deciduous tree	X	X	X
Sapindus saponaria	**Shrub/sapling**	Broad-leaved deciduous tree		X	
Ambrosia trifida	**Herb (field)**	Forb	X		
Toxicodendron radicans	**Herb (field)**	Forb	X		
Elymus virginicus	**Herb (field)**	Graminoid	X	X	X
Muhlenbergia sobolifera	**Herb (field)**	Graminoid	X	X	X

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)
Tamarix ramosissima			invasive but recently nearly eradicated

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: All riparian areas dominated by one or more of the nominal species for this association (*P. deltoides, C. laevigata*, and *U. americana*) as well as *S. nigra*, were placed in this association.

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: Occurring adjacent to banks of Washita River along its east end (northeast part of park) and central portion, as scattered patches along its western end. Also in silted-in old river channels in central eastern end of park and along western half of northern boundary of park.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.1, WABA.7, WABA.17, WABA.18, WABA.23, WABA.28

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL004535 *Sapindus saponaria* Woodland

Translated Name: Western Soapberry Woodland
Common Name: Soapberry Talus and Dune Woodland

Ecological System(s): CES
Status: **Circumscription Confidence: 3**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, and chance historical events. This community occurs on loamy sand or sandy alluvium of old or upper terraces that bound the valley floor of the Washita River. These areas are more rapidly draining and further from the water table than are the adjacent old channels and main valley floor. Composition of tree species at any given site is probably largely dependent on exposure, stage of succession, and chance establishment.

VEGETATION DESCRIPTION

Local Vegetation: This vegetation class varies from nearly closed woodland (50–80% canopy cover) dominated by *Sapindus saponaria* to open (ca. 40% canopy cover) woodland dominated by *Sideroxylon lanuginosum*. The former occurs where succession has apparently operated longer (southern exposure) or progressed faster (northern exposure). In these areas, the invasive *Gymnocladus dioicus* can be codominant along with native *Ulmus americana*. Downslope of these areas, the association merges with the Eastern Cottonwood-American Elm-Sugarberry Forest. The open phase dominated by *Sideroxylon lanuginosum* is only on south-facing terraces. It probably represents an earlier successional stage because *Sapindus saponaria* saplings are usually present and there is no obvious difference in soil texture or elevation from those sites with the more fully developed dominance of *Sapindus saponaria.* The shrub layer is open to sparse, consisting mostly of saplings of the dominant tree species. The ground layer has about a 50% cover and is about a meter tall. It consists mostly of the grasses *Elymus virginicus* and/or *Bromus tectorum*, along with scattered plants of *Chenopodium simplex.*

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Sapindus saponaria	**Tree (canopy & subcan)**	Broad-leaved deciduous tree	X	X	
Ulmus americana	**Tree (canopy & subcan)**	Broad-leaved deciduous tree		X	
Gymnocladus dioicus	**Tree (canopy & subcan)**	Broad-leaved deciduous tree		X	
Sideroxylon lanuginosum	**Tree (canopy & subcan)**	Broad-leaved deciduous tree	X	X	
Sapindus saponaria	**Shrub/sapling**	Broad-leaved deciduous tree	X	X	X
Chenopodium simplex	**Herb (field)**	Forb		X	X
Elymus virginicus	**Herb (field)**	Graminoid	X	X	
Bromus tectorum	**Herb (field)**	Graminoid	X	X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: *Sapindus saponaria* stands at WABA are placed in this association at the moment but the current global concept might not include disturbed and semi-natural stands.

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: This alliance occurs on the upper levels and slopes of old or upper terraces that form the boundary on each side of the valley floor (west end of northern park boundary and the central area of the east end of the park. It also occurs on drainageways and gullies on the lower part of the upland slopes of the park (especially near the old homestead or farmstead) and along the old railroad grade in places, especially where the grade crosses the western end of the park.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.13, WABA.22, WABA.29

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

A.1884 *Prunus angustifolia Shrubland* ALLIANCE

Translated Name: Chickasaw Plum Shrubland Alliance
Common Name: Chickasaw Plum Shrubland Alliance

Ecological System(s): (CES)
Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, past management, and chance historical events. This community occurs on loamy sand and sandy loam soils derived from alluvium on the valley floor immediately back of the main and secondary natural levees bordering the Washita River where the water table is accessible. Occurrences of the community are not uniform in the environment and are probably related to chance establishment of the dominant species and cessation of plowing, mowing, or grazing over the last several decades. Otherwise the environment is similar to that supporting Iva annua – (Xanthium strumarium) Temporarily Flooded Herbaceous Vegetation.

VEGETATION DESCRIPTION

Local Vegetation: This community is dominated by clones of *Prunus angustifolia* with a canopy height of 1–2 m and cover of about 40%. The composition of the ground layer is similar to that of the adjacent Iva annua – (Xanthium strumarium) Temporarily Flooded Herbaceous Vegetation. However, the shading by the plums reduced the herbaceous cover to about 30%.

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Prunus angustifolia	**Short shrub/sapling**	Broad-leaved deciduous tree	X	X	X
Ambrosia psilostachya	**Herb (field)**	Forb	X	X	X
Heterotheca subaxillaris	**Herb (field)**	Forb		X	
Eriogonum annuum	**Herb (field)**	Forb		X	
Cenchrus spinifex	**Herb (field)**	Graminoid		X	
Schizachyrium scoparium	**Herb (field)**	Graminoid		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments:
Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: The community is best developed along the Washita River especially on the north side of the river, where it runs through the central portion of the park. Smaller patches occur further west along both the north and south sides of the river and may occur elsewhere in similar environments.
Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.21

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL001459 *Artemisia filifolia / Andropogon hallii* Shrubland

Translated Name: Sand Sagebrush / Sand Bluestem Shrubland

Ecological Systems:
Central and Upper Texas Coast Salt and Brackish Tidal Marsh (CES203.473)
Western Great Plains Sandhill Steppe (CES303.671)

Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Description: This sagebrush shrubland is found on flat to moderate slopes in the central and southern Great Plains of the United States. The soils are sandy and sandy loams and are somewhat excessively well-drained to excessively well-drained. This community is dominated by evenly spaced shrubs up to 1 m with mid grasses in between. *Artemisia filifolia* is the most abundant shrub, while *Andropogon hallii* is the most abundant herbaceous species. Other associated graminoids include *Bouteloua curtipendula, Bouteloua gracilis, Calamovilfa longifolia, Eragrostis trichodes, Schizachyrium scoparium, Sporobolus cryptandrus*, and *Hesperostipa comata (= Stipa comata)*. Forbs that are typically found in this community include *Helianthus petiolaris, Heterotheca villosa, Lathyrus polymorphus*, and *Psoralidium lanceolatum*. Total vegetation cover is moderately dense to sparse.

In Texas and Oklahoma this association is a grassland with shrubs. Effects of livestock grazing on vegetation structure need to be studied. This type should be better contrasted with *Artemisia filifolia / Schizachyrium scoparium - Andropogon hallii* Shrubland (CEGL002178).

ELEMENT DESCRIPTION

Environment: This community is found on gently to moderately sloping hills. Rarely, it occurs on flat ground. The soils range from loamy fine sands to sand and are somewhat excessively to excessively well-drained (Steinauer 1989, Lauver et al. 1999). The parent material is eolian sand. Johnston (1987) wrote that this community developed principally on the leeward side of major drainageways in southeastern Colorado and southwestern Kansas. In the sandhills of northern Colorado and western Nebraska, this community also occurs away from drainageways (Ramaley 1939b, Steinauer 1989). Drought stress is great due to little precipitation and sandy soil.

Vegetation: This community has an evenly spaced short-shrub layer that reaches 1 m (Bruner 1931). The shrub layer is dominated by *Artemisia filifolia*. The vegetation can be sparse to moderately dense. Ramaley (1939) reported that *Artemisia filifolia* was the dominant species and covered 10% of the ground in a stand in northeastern Colorado. Other common shrubs are *Artemisia frigida, Opuntia* spp., and *Yucca glauca*. Mid and tall grasses dominate between the shrubs. These include *Andropogon hallii, Bouteloua curtipendula, Bouteloua gracilis, Calamovilfa longifolia, Eragrostis trichodes, Schizachyrium scoparium, Sporobolus cryptandrus*, and *Hesperostipa comata (= Stipa comata)*. In Kansas and Nebraska, *Cyperus schweinitzii, Eragrostis secundiflora, Eriogonum annuum, Paspalum setaceum*, and *Grindelia papposa (= Prionopsis ciliata)* are present. Forbs that are found in this community include *Carex duriuscula (= Carex eleocharis), Helianthus petiolaris, Heterotheca villosa, Lathyrus polymorphus*, and *Psoralidium lanceolatum* (Lauver et al. 1999, Steinauer and Rolfsmeier 2000).

ELEMENT GLOBAL RANK & REASONS

GRank: G3?
GReasons: There are probably fewer than 100 occurrences of this community rangewide. It is ranked S2 to S3 in Colorado, Nebraska, Kansas, and Oklahoma, and it is also reported from Texas, New Mexico, and Wyoming. Currently there are no occurrences documented. Historical acreage and trends are unknown; this community has probably been degraded by overgrazing. This community is prominent in the sandhills of western Nebraska and northeastern Colorado.

Other Comments: This type was not sampled at WABA but represents stands that were either too small to sample or were observed in areas surrounding the park.

ELEMENT DISTRIBUTION

Range: This sand sagebrush shrubland is found on flat to moderate slopes in the central and southern Great Plains of the United States, ranging from western Nebraska and possibly Wyoming south to Texas and possibly New Mexico.
Nations: US
States: CO, KS, NE, NM?, OK, TX?, WY?
USFS Ecoregions: 315:C, 321A:CC, 331C:CC, 331H:CC, 331I:CC, 332E:CC

ELEMENT SOURCES

Aldous and Shantz 1924, Baalman 1965, Blair and Hubbell 1938, Bourgeron and Engelking 1994, Bruner 1931, Bunin 1985, CONHP unpubl. data 2003, Costello and Turner 1944, Dahl and Norris 1965, Daley 1972, Diamond 1993, Driscoll et al. 1984, Duck and Fletcher 1945, Evans 1964, Green 1969, Harlan 1957, Hoagland 2000, Johnston 1987, Jones 1963, Kuchler 1974, Lauver et al. 1999, Osborn 1941, Osborn and Kellogg 1943, Ramaley 1916b, Ramaley 1939b, Rogers 1950, Rogers 1953, Savage 1937, Sherwood 1980, Sherwood and Risser 1980, Sims et al. 1976, Smith 1998, Soil Conservation Service 1978, Steinauer 1989, Steinauer and Rolfsmeier 2000, Zanoni et al. 1979

CEGL004016 *Andropogon hallii – Calamovilfa gigantea* Herbaceous Vegetation

Translated Name: Sand Bluestem – Big Sandreed Herbaceous Vegetation
Common Name: Sand Bluestem Prairie

Ecological System(s): Western Great Plains Sand Prairie CES303.670
Status: **Circumscription Confidence: 2**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: Of the typical environmental factors, soils and associated moisture availability appear to be limiting, compared to similar adjacent habitats. This community occurs on loamy sand or sandy alluvium, regardless of whether these soils occur on upland ridge crests, midslope, or slightly elevated levees or old sand dunes of the valley floor of the Washita. These soils are more rapidly draining than are adjacent soils supporting more typical prairie species. Past disturbance and agricultural management has probably reduced species diversity.

VEGETATION DESCRIPTION

Local Vegetation: This vegetation is dominated by *Andropogon hallii*. The canopy is between 1.5 and 2 m tall. Cover varies from 30–50% with the thinner cover occurring in the driest sites. *Schizachyrium scoparium* occurred as a subdominant except at the driest sites. *Artemisia filifolia*, which was also found in adjoining communities is usually present at low densities. The remaining associates were sand-loving forbs (*Astragalus lotiflorus, Croptilon hookerianum, Dalea enneandra, Heterotheca villosa, Liatris pycnostachya, Melilotus officinalis*) and graminoids (*Bouteloua gracilis, Sporobolus cryptandrus*) that occurred at low densities.

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Andropogon hallii	**Herb (field)**	Graminoid	X	X	X
Schizachyrium scoparium	**Herb (field)**	Graminoid		X	
Bouteloua gracilis	**Herb (field)**	Graminoid		X	X
Sporobolus cryptandrus	**Herb (field)**	Graminoid		X	
Artemisia filifolia	**Short shrub/sapling**	Needle-leaved shrub		X	X
Astragalus lotiflorus	**Herb (field)**	Forb		X	X
Croptilon hookerianum	**Herb (field)**	Forb		X	
Dalea enneandra	**Herb (field)**	Forb		X	X
Eriogonum annuum	**Herb (field)**	Forb		X	
Heterotheca villosa	**Herb (field)**	Forb		X	X
Liatris pycnostachya	**Herb (field)**	Forb		X	X
Melilotus officinalis	**Herb (field)**	Forb		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)
Melilotus officinalis			Alien, somewhat invasive

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: The community at WABA is a sand prairie dominated by tallgrasses so it was placed in this global association, however, WABA stands lack *Calamovilfa gigantea* and some other native sand prairie species. The extensive and relatively recent disturbance history and the small number of plots makes it difficult to determine the best global association to place the WABA stands in.

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: In the southeastern part of the park, the community occurs on the ridge crest near the east gate and on the mid-slope above the railroad grade. In the central western part of the park it occurs on old sand dunes or levee crests paralleling the large northward loop of the Washita River. In the southwestern corner of the park it occurs on the contours of the low ridges where coarsest sandy soil outcrops.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.6, WABA.14

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL001464 *Andropogon gerardii – Sorghastrum nutans* Western Great Plains Herbaceous Vegetation

Translated Name: Big Bluestem – Yellow Indiangrass Western Great Plains Herbaceous Vegetation
Common Name: Big Bluestem – Indiangrass Western Great Plains Prairie

Ecological System(s): Western Great Plains Tallgrass Prairie CES303.673
Status: **Circumscription Confidence: 2**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, past management, and fire disturbance. This community occurs on the open valley floor, as well as sloping banks of the main channel, of the Washita River on sandy loam soils derived from alluvium where the water is normally close to the surface. Occurrences of the community are not uniform in the environment and are probably related either to management to re-establish or to survival within the seed/propagule bank of the dominant species. This habitat was used for agriculture previously, but restoration management has included reseeding, prescribed burning, and removal of invasive woody plants. Composition varies with subtle dips in topography. Under natural conditions, the habitat is subject of intermittent flooding. However, flooding of major proportions does not occur as it once did due to impoundments upstream.

VEGETATION DESCRIPTION

Local Vegetation: With a canopy between 1.5 and 2 m high and a cover of 60-80%, this community is dominated by *Sorghastrum nutans*. *Andropogon gerardii* is lacking in this community. *Panicum virgatum* and *Schizachyrium scoparium* are subdominants, except in depressions of old channels and the bank of the main river channel, where the *Panicum virgatum* attains dominance. Where this community occurs on the level areas of the valley floor, the diversity is low, apparently due to recent reseeding of the area with a pure or nearly pure *Sorghastrum nutans* composition. In some areas the weedier grasses *Bothriochloa ischaemum* and *Bothriochloa laguroides* form locally restricted subdominants. Many of the associates currently found (at low densities) in this community are weedy annuals that encroach from neighboring disturbance communities or persist in the seed bank. On the bank of the river channel, the diversity is higher, probably due to this narrow zone never having been used agriculturally. Common associates here are the woody *Amorpha fruticosa* and saplings of *Salix nigra*. In the terrace depression behind the bank and primary natural levee, these two woody species and saplings of *Celtis leavigata* and *Ulmus americana* often formed dense thickets 2–3 meter high or more. This community blends with the Iva annua – (Xanthium strumarium) Temporarily Flooded Herbaceous Vegetation with which it interdigitates and where the densities of the weedy forbs increase.

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Sorghastrum nutans	**Herb (field)**	Graminoid	X	X	X
Panicum virgatum	**Herb (field)**	Graminoid	X	X	X
Schizachyrium scoparium	**Herb (field)**	Graminoid		X	
Bouteloua curtipendula	**Herb (field)**	Graminoid		X	
Muhlenbergia sobolifera	**Herb (field)**	Graminoid		X	
Desmanthus illinoensis	**Herb (field)**	Graminoid		X	X
Solidago gigantea	**Herb (field)**	Graminoid		X	
Teucrium canadense	**Herb (field)**	Graminoid		X	
Amorpha fruiticosa	**Short shrub/sapling**	Broad-leaved deciduous shrub		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)
Tamarix ramosissima			invasive but recently eradicated from this community
Ulmus pumila			Alien, invasive, recent program to eradicate it

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: The differences between the *Panicum virgatum* dominated depressions and the *Sorghastrum nutans* dominated flats were too poorly defined to recognize two separate communities.

It is unclear whether the successional thickets just behind the *Panicum virgatum*-dominated river banks should be considered part of this community, part of the Lowland Herbaceous Disturbance Community, or of the Eastern Cottonwood – American Elm – Sugarberry Forest.

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: This community occurs on most stretches of the main channel of the Washita River, extensive areas of the floodplain south of the river in the northwest and central part of the park, and in more restricted patches in the floodplain north of the river in the western half of the park.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.16, WABA.24, WABA.26, WABA.27, WABA.30

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL001594 *Schizachyrium scoparium – Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation

Translated Name: Little Bluestem – Sideoats Grama Western Great Plains Herbaceous Vegetation
Common Name: Western Great Plains Little Bluestem Mixedgrass Prairie

Ecological System(s): Central Mixedgrass Prairie CES303.659
Status: **Circumscription Confidence: 2**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System:

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, past management, and fire disturbance. This community occurs on convex upland side slopes and step slopes in sandy loam soils derived from sandy shale bedrock. This habitat was used for agriculture previously and generally is less diverse than pristine communities of its class. Restoration management has included prescribed burning and removal of invasive woody plants. Composition varies with changes in topography and degree of invasion or persistence of alien species.

VEGETATION DESCRIPTION

Local Vegetation: Canopy height is about 1.5 m, except on drier sites where it may only reach less than a meter. Due to a high culm-to-leaf growth ratio the canopy cover is only about 50% or a little higher on the areas of lower elevation or richer soil. The community is dominated by *Schizachyrium scoparium* usually with *Bouteloua curtipendula* as an important subdominant. On sites adjacent to sandier soils, *Andropogon hallii* is a conspicuous associate whereas on lower elevation sites with more water availability *Sorghastrum nutans* is a conspicuous associate. Many of the associates currently found (at low densities) in this community are weedy annuals that encroach from neighboring disturbance communities or persist in the seed bank. This community blends with the *Bromus tectorum* Semi-Natural Herbaceous ALLIANCE with which it interdigitates and where the densities of the weedy forbs increase.

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Schizachyrium scoparium	**Herb (field)**	Graminoid	X	X	X
Bouteloua curtipendula	**Herb (field)**	Graminoid		X	X
Andropogon hallii	**Herb (field)**	Graminoid		X	
Sorghastrum nutans	**Herb (field)**	Graminoid		X	
Melilotus officinalis	**Herb (field)**	Forb			X
Ambrosia psilostachya	**Herb (field)**	Forb			X
Grindelia papposa	**Herb (field)**	Forb		X	
Heterotheca subaxillaris	**Herb (field)**	Forb		X	
Symphyotrichum ericoides	**Herb (field)**	Forb		X	X

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)
Melilotus officinalis			Alien, somewhat invasive
Ulmus pumila			Alien, invasive, recent program to eradicate it

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments:

Local Other Comments: In certain, usually small, areas where restoration is poor, *Bothriochloa ischaemum* replaced the dominant grass species. None of these areas were in the sample plots, but observation points (with GPS data) were taken for several of these areas.

ELEMENT DISTRIBUTION

Local Range: The vegetation class occurs in about half of the southeast corner of the park, much of the slope north and west of the overlook, and much of the western end of the park south of the railroad grade.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.5, WABA.9, WABA.25

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

A.1232 *Pascopyrum smithii* Herbaceous ALLIANCE

Translated Name: Western Wheatgrass Herbaceous Alliance
Common Name:

Ecological System(s): (CES)
Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, human disturbance, and possibly chance historical events. This community occurs on sandy loam that has been scraped, covered, and mixed with various rock gravels along and adjacent to the railroad grade. Undoubtedly the gravel has altered the chemical and physical qualities of the soil. In the park, the community is limited to these disturbed areas. Dispersal of seeds of the dominant from passing trains may have also been a factor in its establishment.

VEGETATION DESCRIPTION

Local Vegetation: The vegetation generally is less than 0.5 m high and forms a dense cover of about 80%. It is strongly dominated by *Pascopyrum smithii.* Associates consists of weedy native and alien forbs and grasses, the most common being *Acalypha ostryifolia* and *Bromus japonicus.* The composition of the associated species varies along the length of this linear habitat. In sites with somewhat great water availability *Sorghum halepense* is common.

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Pascopyrum smithii	**Herb (field)**	Graminoid	X	X	X
Bromus japonicus	**Herb (field)**	Graminoid		X	X
Panicum obtusum	**Herb (field)**	Graminoid		X	
Acalypha ostryifolia	**Herb (field)**	Forb		X	X
Artemisia ludoviciana	**Herb (field)**	Forb		X	
Chamaesyce glyptosperma	**Herb (field)**	Forb		X	
Conyza canadensis	**Herb (field)**	Forb		X	
Mollugo verticillata	**Herb (field)**	Forb		X	
Physalis cinerascens	**Herb (field)**	Forb		X	
Solanum elaeagnifolium	**Herb (field)**	Forb		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: This community, due to its small extent, was sampled with a single plot. Therefore, the variation is probably not well sampled.
Local Other Comments: This merged with disturbance communities where moisture regimes allowed alien species, such as *Sorghum halapense* to be common.

ELEMENT DISTRIBUTION

Local Range: This community was limited to the railroad grade but was developed in most areas along the grade's length.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.10

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL001754 *Bouteloua gracilis – Bouteloua curtipendula* Herbaceous Vegetation

Translated Name: Blue Grama – Sideoats Grama Herbaceous Vegetation
Common Name: Blue Grama – Sideoats Grama Shortgrass Prairie

Ecological System(s): Western Great Plains Shortgrass Prairie CES303.672
Status: **Circumscription Confidence: 2**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, past management, and fire disturbance. This community occurs on convex upland ridge crests in sandy loam soils derived from sandy shale bedrock, as well as on shale outcrop mounds. These habitats are better drained then sandy loam on side slopes, and retain moisture better than the loamy sands in adjacent areas. The shale mounds host the most diverse representations of this vegetation because, unlike the rounded ridgetops, these mounds were not used agriculturally. Restoration management has included prescribed burning.

VEGETATION DESCRIPTION

Local Vegetation: This vegetation is generally below a meter tall and cover varies from about 60% on the rounded ridges to only 30% on the shale mounds. *Bouteloua gracilis* dominates in both areas. *Bouteloua curtipendula* is a co- to sub-dominant on the lower diversity rounded crests, but it becomes sparse upward on the drier, exposed shale mounds. On the rounded crests, the remaining associates are mixed prairie species, such as *Aristida purpurea, Schizachyrium scoparium*, and *Sporobolus* spp. On the shale mounds the associates were more typical of rocky prairies, such as *Mimosa borealis, Yucca glauca, Paronychia jamesii,* and *Scutellaria resinosa.*

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Bouteloua gracilis	**Herb (field)**	Graminoid	X	X	X
Bouteloua curtipendula	**Herb (field)**	Graminoid	X	X	
Aristida purpurea	**Herb (field)**	Graminoid		X	X
Schizachyrium scoparium	**Herb (field)**	Graminoid		X	
Mimosa borealis	**Short shrub/sapling**	Thorn shrub		X	
Yucca glauca	**Short shrub/sapling**	Other shrub		X	
Ambrosia psilostachya	**Herb (field)**	Forb			X
Paronychia jamesii	**Herb (field)**	Forb		X	
Scutellaria resinosa	**Herb (field)**	Forb		X	
Calylophus hartwegii	**Herb (field)**	Forb		X	
Amphiachyris dracunculoides	**Herb (field)**	Forb		X	
Chamaecrista fasciculata	**Herb (field)**	Forb		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments:

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: This vegetation class is limited to the rounded ridge crest and shale outcrop mound about 100 m northeast of the outlook.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.2, WABA.4

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL00XXXX *Iva annua – (Xanthium strumarium)* Temporarily Flooded Herbaceous Vegetation

Translated Name: Sumpweed – (Cockleburr) Temporarily Flooded Herbaceous Vegetation
Common Name: Japanese knotweed Gravelbar

Ecological System(s): (CES)
Status: Standard **Circumscription Confidence:** 3
Concept Author(s): B. Hoagland, M. Pyne

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, past management, and chance historical events. This community occurs on loamy sand and sandy loam soils derived from alluvium on the open valley floor of the Washita River. Occurrences of the community are not uniform in the environment and are probably related to chance establishment of the species dominants in localized patches and to cessation of plowing, mowing, or grazing over the last several decades. Flooding of major proportions does not occur as it once did due to impoundments upstream and hence, does not probably have much effect on present species composition.

VEGETATION DESCRIPTION

Local Vegetation: The structure and composition of this vegetation is variable and patchy. In general the canopy is 1–2 m high and cover is about 50–70%. The most common species that form patch dominants or subdominants are *Ambrosia psilostachya*, *Ambrosia trifida, Bromus japonicus, Bromus tectorum, Conyza canadensis*, and *Iva annua*. A number of native grasses (*Bouteloua curtipendula, Panicum capillare*, *Panicum virgatum, Schizachyrium scoparium, Sorghastrum nutans, Sporobolus vaginiflorus*, and *Tridens flavus*) and forbs (*Desmanthus illinoensis, Gaura* spp., *Grindelia papposa, Helianthus annuus,* and *Solanum elaeagnifolium*) are frequently associated by at low densities. *Sorghum halapense* formed small scattered patches. In particular depressions of old channels are characterized by colonies (as nearly pure stands) of *Ambrosia trifida* or *Iva annua.* On the terraces nearer to the river channel, saplings of *Celtis laevigata, Salix nigra*, and *Ulmus americana* become common and the community merges with successional stands of shrublands/woodlands (*Prunus angustifolia* Shrubland or *Populus deloides – Celtis laevigata / Ulmus americana* Woodland).

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Bromus japonicus	**Herb (field)**	Graminoid	X	X	X
Bromus tectorum	**Herb (field)**	Graminoid		X	
Panicum capillare	**Herb (field)**	Graminoid		X	
Sorghastrum nutans	**Herb (field)**	Graminoid		X	
Ambrosia psilostachya	**Herb (field)**	Forb	X	X	X
Ambrosia trifida	**Herb (field)**	Forb	X	X	
Conyza canadensis	**Herb (field)**	Forb	X	X	
Grindelia papposa	**Herb (field)**	Forb	X	X	X
Helianthus annuus	**Herb (field)**	Forb		X	
Heterotheca subaxillaris	**Herb (field)**	Forb		X	
Iva annua	**Herb (field)**	Forb	X	X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)
Ulmus pumila			Alien, invasive, recent program to eradicate it

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: This may need to be combined with the Bromus tectorum Semi-natural Herbaceous Alliance. However, soil and moisture factors, as well as combinations of dominants, defines each of these vegetation types.

It is not clear whether the successional shrubland phase should be separated as a distinct vegetation class.

Local Other Comments: Some areas of the floodplain on the south side of the Washita River were characterized by dominance of Old World bluestem and silver bluestem (*Bothriochloa ischaemum* and *Bothriochloa laguroides)*. These were given observation points but were not sampled directly.

ELEMENT DISTRIBUTION

Local Range: Occurs throughout the Washita floodplain interdigitating with Andropogon gerardii – Sorghastrum nutans Western Great Plains Herbaceous Vegetation.
Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:
Local Inventory Notes:
Local Plots: WABA.11, WABA.15, WABA.19
Local Description Author(s): R. Sanders
References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

CEGL005989 *Schoenoplectus pungens – Paspalum distichum* Herbaceous Vegetation

Translated Name: Threesquare – Joint Crowngrass Herbaeous Vegetation
Common Name:

Ecological System(s): (CES)
Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: This environment consists of depositional silt- and sand-bars and lowest channel banks of the Washita River where the substrate remains near saturation and inundation of the community is frequent. Composition of communities appears to be controlled largely by chance establishment following major flooding that shifts the structure of the depositional bars and by tolerance of persistently saturated root environments.

VEGETATION DESCRIPTION

Local Vegetation: Composition within community depends on elevation above mean water level. The tops of bars and lower bank are dominated by dense canopies of *Panicum virgatum* and *Echinochloa crus-galli.* The next wetter zone below this is dominated by more open covers of *Paspalum distichum* and *Schoenoplectus pungens.* Below this the open wet silt, sand, and gravel was generally bare except for small patches of *Cyperus odoratus*, *Eleocharis montevidens,* and *Fimbristylis vahlii*. Therefore, the canopy drops from about 2 m to substrate surface and covers from 80% to 0% of the substrate. Common associates are *Leersia oryzoides, Panicum capillare, Pluchea carolinensis, Polygonum lapathifolium*, and *Xanthium strumarium.*

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Echinochloa crus-galli	**Herb (field)**	Graminoid	X	X	X
Panicum virgatum	**Herb (field)**	Graminoid	X	X	X
Paspalum distichum	**Herb (field)**	Graminoid	X	X	X
Schoenoplectus pungens	**Herb (field)**	Graminoid	X	X	X
Panicum capillare	**Herb (field)**	Graminoid		X	
Cyperus odoratus	**Herb (field)**	Graminoid		X	X
Eleocharis montevidens	**Herb (field)**	Graminoid		X	X
Fimbristylis vahlii	**Herb (field)**	Graminoid		X	X
Leersia oryzoides	**Herb (field)**	Graminoid		X	
Pluchea carolinensis	**Herb (field)**	Forb		X	X
Polygonum lapathifolium	**Herb (field)**	Forb		X	
Xanthium strumarium	**Herb (field)**	Forb		X	X
Iva annua	**Herb (field)**	Forb		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments: This community may be too small to map but is conspicuous and distinctive in the field.

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: The community is found in the bed of the main channel of the Washita River wherever the channel makes a convex bend or where the bank has a concave base that does not drop directly to the water line.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.20, WABA.31

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

A.1814 *Bromus tectorum* Semi-Natural Herbaceous ALLIANCE

Translated Name: Cheatgrass Semi-Natural Herbaceous Alliance
Common Name:

Ecological System(s): (CES)
Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Summary:

ENVIRONMENTAL DESCRIPTION

Local Environment: The environmental factors that influence the composition and structure of this community are: climate, soils, topography, past management, and chance historical events. This community occurs on sandy loam and loamy sand soils derived from sandy shale substrates on upper, side and lower upland slopes. It is also found in small areas of deep sand from the remnants of old natural raised levees and/or sand dunes behind the primary and secondary levees paralleling the Washita River. Occurrences of the community are not uniform in the environment and are probably related to soil texture/water availability, to chance establishment of the species dominants in localized patches, to cessation of plowing, mowing, or grazing over the last several decades, and to the recent implementation of prescribed burns.

VEGETATION DESCRIPTION

Local Vegetation: The structure and composition of this vegetation is variable and patchy. In the moister sites the canopy is 1–2 m high and cover is about 70–80%. On the drier deep sands, the canopy is less than 1 meter and cover is 50–60%. Generally, the most common species that form patch dominants or subdominants are *Ambrosia psilostachya*, *Bromus tectorum, Bromus japonicus, Grindelia papposa,* and *Helianthus annuus*. Associated with these are the native grasses (*Bouteloua curtipendula, Bothriochloa laguroides*, *Pascopyrum smithii,* and *Sporobolus* spp.) and forbs (*Conyza canadensis*, *Cucurbita foetidissima,* and *Solanum elaeagnifolium*) are frequently associated at low densities. *Melilotus officinalis* is invasive in the moister sites. *Sorghum halapense* and *Kochia scoparia* formed small scattered patches. However, on the drier sites of deep sands the dominants are *Bromus japonicus, Heterotheca subaxillaris*, and *Ambrosia psilostachya* with the primary associates being *Artemisia filifolia, Croptilon hookerianum, Eriogonum annuum, Mentzelia nuda, Conyza canadensis*, and *Triplasis purpurea.*

LOCAL FLORISTIC COMPOSITION

Species Name	Stratum	Lifeform	Dom	Char	Const
Bromus tectorum	**Herb (field)**	Graminoid	X	X	X
Bromus japonicus	**Herb (field)**	Graminoid	X	X	X
Bouteloua curtipendula	**Herb (field)**	Graminoid		X	
Bothriochloa laguroides	**Herb (field)**	Graminoid		X	
Pascopyrum smithii	**Herb (field)**	Graminoid		X	
***Sporobolus* spp.**	**Herb (field)**	Graminoid		X	
Triplasis purpurea	**Herb (field)**	Graminoid		X	
Ambrosia psilostachya	**Herb (field)**	Forb	X	X	X
Artemisia filifolia	**Short shrub/sapling**	Needle-leaved shrub		X	
Conyza canadensis	**Herb (field)**	Forb		X	X
Croptilon hookerianum	**Herb (field)**	Forb		X	
Eriogonum annuum	**Herb (field)**	Forb		X	
Grindelia papposa	**Herb (field)**	Forb	X	X	
Helianthus annuus	**Herb (field)**	Forb	X	X	
Heterotheca subaxillaris	**Herb (field)**	Forb	X	X	
Melilotus officinalis	**Herb (field)**	Forb		X	
Mentzelia nuda	**Herb (field)**	Forb		X	

LOCAL OTHER NOTEWORTHY SPECIES

Species Name	GRank	Animal	Note (*specify Rare (geog area), Invasive, Animal, or Other*)
Melilotus officinalis			Alien, somewhat invasive
Ulmus pumila			alien, invasive, recent program to eradicate it

CLASSIFICATION & OTHER COMMENTS

Local Classification Comments:

Local Other Comments:

ELEMENT DISTRIBUTION

Local Range: This community occurs across the eastern end and central portion of the upland in the south part of the park where it interdigitates with the *Schizachyrium scoparium – Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation and *Andropogon hallii – Calamovilfa gigantea* Herbaceous Vegetation. Small patches occur in isolated openings on the upper terraces along the western end of the north boundary of the park. In the floodplain it occurs on raised natural levees or old sand dunes on the north side of the Washita River in the center and western end of the park and on the south side of the river in the center of the park.

Nations: US

ELEMENT SOURCES

Local Map Units:

Map Unit Name	Relationship	Note

Local Map Units Summary:

Local Inventory Notes:

Local Plots: WABA.3, WABA.8, WABA.12

Local Description Author(s): R. Sanders

References

Reference (*=concept ref)	name	classif	related	char	rank	eospec	eorank	manage	image
Ecology Working Group n.d.*	X°								

A.1343 *Panicum virgatum* Temporarily Flooded Herbaceous Alliance

Translated Name: Switchgrass Temporarily Flooded Herbaceous Alliance
Common Name: (CES)

Ecological System(s): Central and Upper Texas Coast Salt and Brackish Tidal Marsh (CES203.473)
Western Great Plains Sandhill Steppe (CES303.671)

Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Description: This alliance encompasses temporarily flooded areas dominated by the nominal species with other perennial graminoids and forbs. Associated species vary with geography and substrate. These may include *Juncus* spp., *Solidago* spp., *Eupatorium* spp., *Toxicodendron radicans, Campsis radicans, Polygonum* spp., and *Panicum* spp. This community is variable in its expression, but *Panicum virgatum* tends to be the tallest plant and to represent most of the biomass. Variability occurs in the cover of *Panicum virgatum* and the richness of associated species. Grasses constitute most of the biomass. Shrubs, if present, will constitute less than 10% cover; these may include *Morella cerifera (= Myrica cerifera), Alnus serrulata, Amorpha nitens, Baccharis halimifolia, Betula nigra, Hypericum densiflorum, Ilex decidua*, or *Salix nigra*. This alliance may develop as zoned herbaceous vegetation on rocky riverbank complexes along larger rivers in the Ouachita Mountains (D. Zollner pers. comm.), as cobble/boulder bars such as in Kentucky along the Ohio River (J. Campbell pers. comm.), or sandbars of Coastal Plain rivers in Mississippi and other states. These sites receive water input from the rivers during flood events, becoming dry during rainless intervals. Other associations may remain to be described in this alliance, and its complete range of variation described.

ELEMENT DESCRIPTION

Environment: This alliance may develop as zoned herbaceous vegetation on rocky riverbank complexes along larger rivers in the Ouachita Mountains (D. Zollner pers. comm.), as cobble/boulder bars such as in Kentucky along the Ohio River (J. Campbell pers. comm.), or sandbars of coastal plain rivers in Mississippi and other states. These sites receive water input from the rivers during flood events, becoming dry during rainless intervals.

Vegetation: This alliance encompasses temporarily flooded areas dominated by the nominal species with other perennial graminoids and forbs. Associated species vary with geography and substrate. These may include *Juncus* spp., *Solidago* spp., *Eupatorium* spp., *Toxicodendron radicans, Campsis radicans, Polygonum* spp., and *Panicum* spp. This community is variable in its expression, but *Panicum virgatum* tends to be the tallest plant and to represent most of the biomass. Variability occurs in the cover of *Panicum virgatum* and the richness of associated species. Grasses constitute most of the biomass. Shrubs, if present, will constitute less than 10% cover; these may include *Morella cerifera (= Myrica cerifera), Alnus serrulata, Amorpha nitens, Baccharis halimifolia, Betula nigra, Hypericum densiflorum, Ilex decidua*, or *Salix nigra*.

Other Comments: This type was not sampled at WABA but represents stands that were either too small to sample or were observed in areas surrounding the park.

ELEMENT DISTRIBUTION

Range: This alliance is found in Arkansas, Kentucky, Mississippi, Texas, and possibly in Alabama (?), Florida (?), Georgia (?), Louisiana (?), Oklahoma (?), and the Mexican state of Coahuila (?).
Nations: US, MX
States: AL?, AR, FL?, GA?, LA?, MS, OK, TX

ELEMENT SOURCE

Campbell, Julian J. N. Personal communication. Kentucky Field Office, The Nature Conservancy., Foti et al. 1994, Southeastern Ecology Working Group of NatureServe. No date, Zollner, Douglas. Personal communication. Ecologist, The Nature Conservancy, Arkansas Field Office, Little Rock.

A.2020 *Sorghum halepense* Herbaceous Alliance

Translated Name: Johnsongrass Herbaceous Alliance
Common Name:

Ecological System(s):
Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Description: This alliance occurs in old fields and along the edges of roads and fields in the southeastern United States. This alliance includes herbaceous vegetation heavily dominated by *Sorghum halepense* which is a tall-growing, robust, and weedy non-native grass. Other non-native grasses, such as *Phleum pratense, Lolium arundinaceum, Setaria parviflora*, and *Digitaria ischaemum* may be present at lower cover values. *Andropogon* spp., *Cyperus* spp., and *Carex cherokeensis*, are other (native) graminoids which may be present. Forbs include *Melothria pendula, Commelina communis, Cocculus carolinus, Erechtites hieraciifolia, Lactuca floridana, Rumex* sp., *Diodia virginiana, Trifolium pratense, Solanum carolinense*, and *Chamaesyce maculata (= Euphorbia maculata)*.

ELEMENT DESCRIPTION

Environment: This alliance occurs in old fields and along the edges of roads and fields. *Sorghum halepense* is kept out of agricultural fields with herbicides but can colonize after cultivation ceases. *Sorghum halepense* is considered to be one of the ten worst invasive weeds in the world (Holm et al. 1977).

Vegetation: This alliance includes herbaceous vegetation heavily dominated by *Sorghum halepense* which is a tall-growing, robust and weedy non-native grass. Other non-native grasses, such as *Phleum pratense, Lolium arundinaceum, Setaria parviflora*, and *Digitaria ischaemum* may be present at lower cover values. *Andropogon* spp., *Cyperus* spp., and *Carex cherokeensis*, are other (native) graminoids which may be present. Forbs include *Melothria pendula, Commelina communis, Cocculus carolinus, Erechtites hieraciifolia, Lactuca floridana, Rumex* sp., *Diodia virginiana, Trifolium pratense, Solanum carolinense*, and *Chamaesyce maculata (= Euphorbia maculata)*.

Other Comments: This type was not sampled at WABA but represents stands that were either too small to sample or were observed in areas surrounding the park.

ELEMENT DISTRIBUTION

Range: This alliance is presumably widespread in agricultural regions of the southeastern United States.
Nations: US
States:

ELEMENT SOURCES

Holm et al. 1977, Southeastern Ecology Working Group of NatureServe. No date.

A.1343 *Cynodon dactylon* Herbaceous Alliance

Translated Name: Bermuda Grass Herbaceous Alliance
Common Name:

Ecological System(s):
Status: **Circumscription Confidence:**
Concept Author(s):

ELEMENT CONCEPT

Global Description: Pastures of the southeastern Coastal Plain and other adjacent ecoregions, found in Florida, Georgia, Oklahoma, and other states, dominated by the introduced grass *Cynodon dactylon*. Although originally planted, *Cynodon dactylon* maintains itself spontaneously, though especially with continued grazing or mowing, and this vegetation is considered 'semi-natural.' Various remnant native species occur to varying degrees, and are sometimes codominant.

ELEMENT DESCRIPTION

Environment: This vegetation is weedy (dominated by an exotic species), but self-reproducing, and is found in pastures, where it maintains itself spontaneously, aided by grazing or mowing. Although originally planted, this vegetation maintains itself spontaneously and is considered weedy or "semi-natural" as opposed to cultivated.

Vegetation: Pastures dominated by the introduced grass *Cynodon dactylon*, with various remnant native species. Although originally planted, *Cynodon dactylon* maintains itself spontaneously and is considered weedy or "semi-natural" as opposed to cultivated. Stands in Oklahoma may contain *Ambrosia artemisiifolia, Amphiachyris dracunculoides*, and *Melilotus officinalis (= Melilotus albus)* (Hoagland 2000). These communities are dominated by low-stature graminoids

Other Comments: This type was not sampled at WABA but represents stands that were either too small to sample or were observed in areas surrounding the park.

ELEMENT DISTRIBUTION

Range: This alliance is found in Florida, Georgia, Oklahoma, and possibly other states, primarily in the southeastern Coastal Plain, but also in other adjacent ecoregions
Nations: US
States:

ELEMENT SOURCES

Hoagland 2000, Southeastern Ecology Working Group of NatureServe. No date.

APPENDIX E: WABA Species List

This is not a complete list of species for WABA. This list only contains the species recorded for the 2005 sample plots and the 2006 accuracy assessment points. Genus-only records indicate an unknown species.

Family	Scientific Name	Common Name
Agavaceae	*Yucca glauca*	yucca
Anacardiaceae	*Rhus glabra*	smooth sumac
	Rhus trilobata	
	Toxicodendron radicans	
Apocynaceae	*Apocynum cannabinum*	Indianhemp
Asclepiadaceae	*Asclepias arenaria*	
Asteraceae	*Ambrosia psilostachya*	Cuman ragweed
	Ambrosia trifida	
	Amphiachyris dracunculoides	prairie broomweed
	Artemisia campestris	field sagewort
	Artemisia filifolia	sand sagebrush
	Artemisia ludoviciana	white sagebrush
	Cirsium undulatum	
	Conyza canadensis	
	Croptilon hookerianum	
	Eclipta prostrata	false daisy
	Erigeron bellidiastrum	
	Eupatorium serotinum	
	Gaillardia	
	Grindelia nuda	
	Grindelia papposa	Spanish gold
	Helianthus annuus	common sunflower
	Helianthus maximiliani	
	Heterotheca subaxillaris	
	Heterotheca villosa	hairy false goldenaster
	Hymenopappus flavescens	
	Iva annua	sumpweed
	Lactuca serriola	
	Liatris pycnostachya	
	Pluchea odorata	
	Solidago canadensis	Canada goldenrod
	Solidago gigantea	giant goldenrod
	Symphyotrichum ericoides var. ericoides	white heath aster
	Symphyotrichum subulatum	eastern annual saltmarsh aster
	Thelesperma megapotamicum	
	Verbesina encelioides	
	Vernonia baldwinii	
	Xanthisma texanum	
	Xanthium strumarium	
Brassicaceae	*Arabis canadensis*	sicklepod

	Dimorphocarpa candicans	Palmer's spectaclepod
Cactaceae	*Opuntia macrorhiza*	
Caryophyllaceae	*Paronychia jamesii*	
Chenopodiaceae	*Chenopodium*	goosefoot
	Chenopodium album	lambsquarters
	Chenopodium simplex	mapleleaf goosefoot
	Kochia scoparia	Mexican-fireweed
Commelinaceae	*Commelina erecta*	
	Commelina erecta var. angustifolia	whitemouth dayflower
Cucurbitaceae	*Cucurbita foetidissima*	
Cupressaceae	*Juniperus virginiana*	
Cyperaceae	*Carex gravida*	
	Cyperus odoratus	
	Cyperus schweinitzii	
	Cyperus strigosus	
	Eleocharis montevidensis	
	Fimbristylis vahlii	
	Schoenoplectus pungens	
Euphorbiaceae	*Acalypha ostryifolia*	
	Chamaesyce glyptosperma	
	Croton glandulosus	
	Croton texensis	Texas croton
	Euphorbia dentata	
	Euphorbia hexagona	
Fabaceae	*Amorpha fruticosa*	desert false indigo
	Astragalus lotiflorus	
	Astragalus plattensis	
	Chamaecrista fasciculata	
	Chamaecrista fasciculata var. fasciculata	sleepingplant
	Dalea enneandra	nineanther prairie clover
	Dalea villosa	
	Desmanthus illinoensis	prairie bundleflower
	Gleditsia triacanthos	
	Gymnocladus dioicus	Kentucky coffeetree
	Indigofera miniata	coastal indigo
	Melilotus officinalis	yellow sweetclover
	Mimosa borealis	
	Mimosa nuttallii	
	Strophostyles leiosperma	
Krameriaceae	*Krameria lanceolata*	
Lamiaceae	*Salvia azurea*	azure blue sage
	Scutellaria wrightii	
	Teucrium canadense	Canada germander
Loasaceae	*Mentzelia nuda*	
Lythraceae	*Ammannia coccinea*	
Menispermaceae	*Cocculus carolinus*	
Molluginaceae	*Mollugo verticillata*	
Moraceae	*Morus alba*	

	Morus rubra	red mulberry
Nyctaginaceae	*Mirabilis nyctaginea*	
Oleaceae	*Forestiera pubescens*	stretchberry
Onagraceae	*Calylophus hartwegii*	
	Gaura mollis	velvetweed
	Gaura villosa	
Plantaginaceae	*Plantago patagonica*	
Poaceae	*Andropogon hallii*	sand bluestem
	Aristida oligantha	
	Aristida purpurea	purple threeawn
	Bothriochloa ischaemum	
	Bothriochloa laguroides	
	Bothriochloa pertusa	pitted beardgrass
	Bouteloua curtipendula	sideoats grama
	Bouteloua gracilis	blue grama
	Bouteloua hirsuta	hairy grama
	Bromus	brome
	Bromus japonicus	Japanese brome
	Bromus tectorum	cheatgrass
	Buchloe dactyloides	buffalograss
	Cenchrus spinifex	
	Chloris	windmill grass
	Cynodon dactylon	Bermudagrass
	Echinochloa crus-galli	
	Elymus canadensis	
	Elymus virginicus	Virginia wildrye
	Eragrostis curvula	
	Eragrostis spectabilis	
	Leersia oryzoides	
	Muhlenbergia racemosa	
	Muhlenbergia sobolifera	rock muhly
	Panicum capillare	witchgrass
	Panicum obtusum	
	Panicum virgatum	switchgrass
	Pascopyrum smithii	western wheatgrass
	Paspalum	crowngrass
	Paspalum distichum	
	Paspalum setaceum	thin paspalum
	Poa arachnifera	
	Schizachyrium scoparium	little bluestem
	Setaria parviflora	marsh bristlegrass
	Sorghastrum nutans	Indiangrass
	Sorghum halepense	Johnsongrass
	Spartina pectinata	
	Sporobolus compositus	composite dropseed
	Sporobolus compositus var. drummondii	
	Sporobolus cryptandrus	sand dropseed
	Sporobolus vaginiflorus	poverty dropseed

	Tridens flavus	purpletop tridens
	Triplasis purpurea	
Polygonaceae	*Eriogonum annuum*	annual buckwheat
	Eriogonum longifolium	
	Polygonum lapathifolium	
Primulaceae	*Primula angustifolia*	alpine primrose
Ranunculaceae	*Delphinium carolinianum*	
Rosaceae	*Prunus angustifolia*	Chickasaw plum
Rubiaceae	*Cephalanthus occidentalis*	common buttonbush
Salicaceae	*Populus deltoides*	eastern cottonwood
	Salix nigra	black willow
Sapindaceae	*Sapindus saponaria*	wingleaf soapberry
Sapotaceae	*Sideroxylon lanuginosum*	gumbully
Scrophulariaceae	*Castilleja purpurea*	
Solanaceae	*Physalis cinerascens*	
	Solanum elaeagnifolium	silverleaf nightshade
Tamaricaceae	*Tamarix ramosissima*	saltcedar
Ulmaceae	*Celtis laevigata*	sugarberry
	Ulmus americana	American elm
	Ulmus pumila	Siberian elm
Verbenaceae	*Glandularia pumila*	
	Phyla lanceolata	
Vitaceae	*Cissus trifoliata*	sorrelvine
	Parthenocissus quinquefolia	Virginia creeper
	Vitis acerifolia	

APPENDIX F: Photo Interpretation Mapping Conventions and Visual Key

Washita Battlefield National Historic Site - Map Units

This section describes the map units for the Washita Battlefield National Historic Site Vegetation Mapping Project. Its purpose is to:

- Describe the vegetation of each map unit;
- Provide a ground photo image for each map unit;
- Describe the link between each map unit and the U.S. National Vegetation Classification;
- Provide visual examples of each map unit with aerial photographs and delineated overlays.

The map units for WABA were based on a combination of NVC plant associations/alliances, local requests (i.e. Park Specials), the limitations of the digital imagery, and land-use / land-cover classes. The vegetation described in this section reflects the classification designed specifically for this project. Lookup tables that include the names of each code are included on the DVD. Non-vegetated map units are not described in this key.

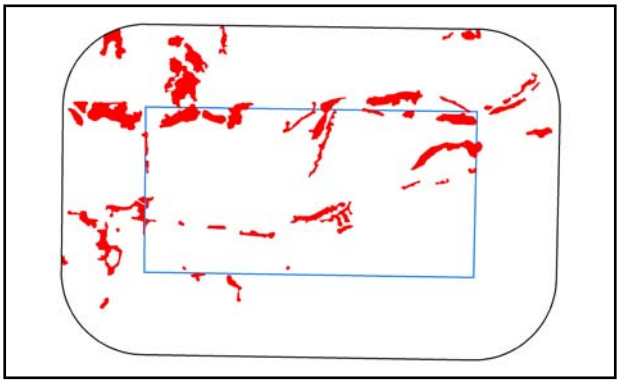
Each map unit is described by a variety of characteristics and features. These include vegetation descriptions, a ground photograph, and example digital imagery signatures taken from the 2005 true color NAIP digital orthophoto used as a basemap for this project. Many of the map unit descriptions rely heavily on the vegetation descriptions for the corresponding associations/alliances provided by NatureServe. Each map unit is typically made up of one vegetation association or alliance as listed. The sample ground photographs are from a variety of sources including ground photos of the sample plots and photos taken during signature verification trips or provided by Roger Sanders.

Forests and Woodlands

F-COTW *Populus deltoides - Ulmus americana - Celtis laevigata* Forest
Eastern Cottonwood - American Elm - Sugarberry Forest

Associations and Alliances
Populus deltoides - Ulmus americana - Celtis laevigata Forest

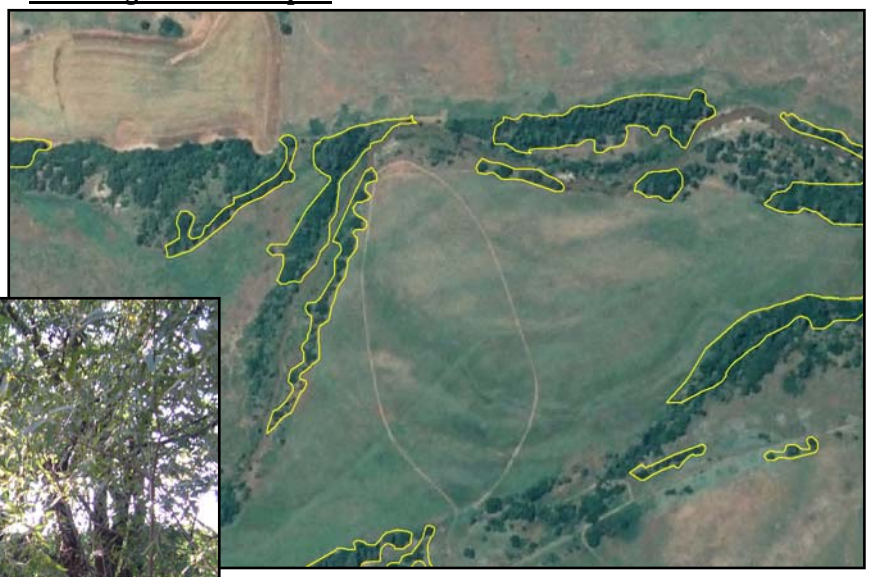
Range and Distribution



Common Species
Populus deltoides
Salix nigra
Ulmus americana
Celtis laevigata
Sapindus saponaria
Ambrosia trifida
Toxicodendron radicans
Elymus virginicus
Muhlenbergia sobolifera

Description
This was the most common forest/woodland type at WABA occurring on the banks of Washita River, as scattered patches and in old river channels. This type was usually dominated by one or more of the nominal species for this association (*P. deltoides*, *C. laevigata*, and *U. americana*). The understory was usually varied ranging from lush, multi-strata diverse stands to stands with a sparse herbaceous layer. This type intermixed with both *Salix nigra* and *Sapindus saponaria* in some areas and this may have led to some confusion in mapping them separately. On the imagery this type appeared as dense stands of dark green trees.

Photo Signature Examples



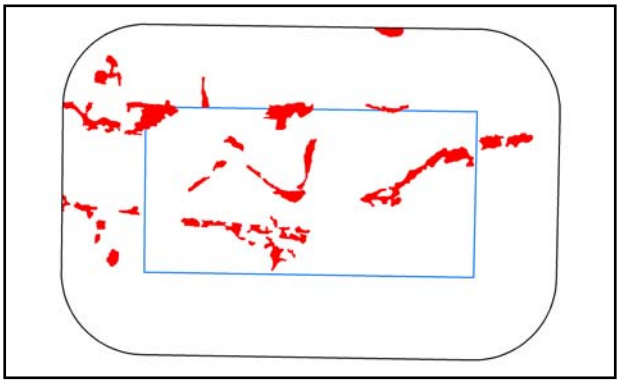
Representative Ground Photo

W-WTSB *Sapindus saponaria* Woodland
Western Soapberry Woodland

Associations and Alliances
Sapindus saponaria Woodland

Common Species
Sapindus saponaria
Ulmus americana
Gymnocladus dioicus
Sideroxylon lanuginosum
Chenopodium simplex
Elymus virginicus
Bromus tectorum

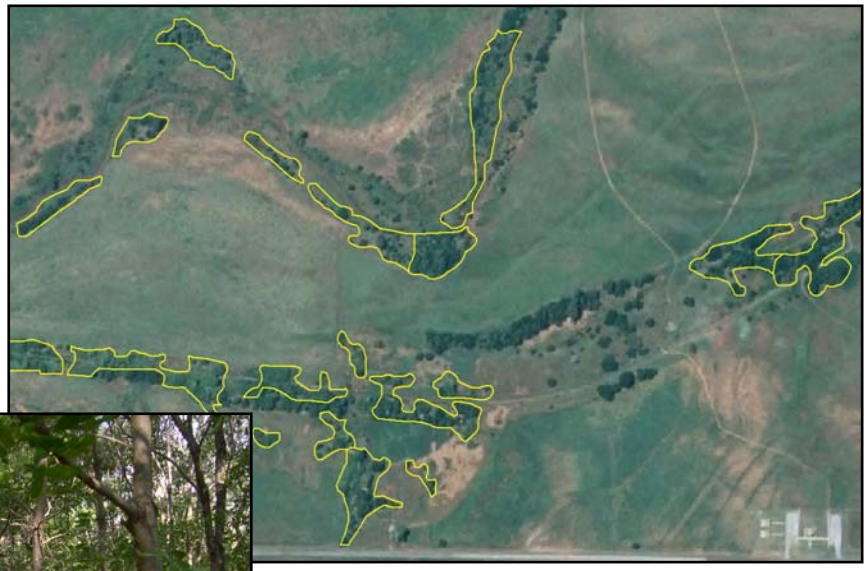
Range and Distribution



Description

This alliance is a common woodland at WABA occurring on the upper levels and slopes of old terraces and in drainageways and gullies. This type is characterized by the dominance of soapberry but may also contain high cover from other deciduous trees such as *Ulmus americana*. This intermixing of deciduous tree species is common in all of the woodland/forest types at WABA and may have led to some confusion during the mapping. On the imagery stands of this type had a lighter green color than the cottonwoods and usually had a white/gray speckling.

Photo Signature Examples



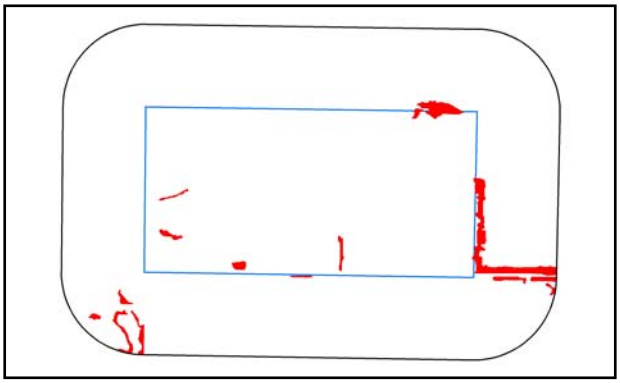
Representative Ground Photo

W-SELM *Ulmus pumila* Woodland Stand
Siberian Elm Woodland Stand

Associations and Alliances
Local Stand (no NVC Alliance at this time)

Common Species
Ulmus pumila
Populus deltoides
Schizachyrium scoparium
Sporobolus compositus
Chloris sp.

Range and Distribution



Description
This type rarely occurred in isolated areas in WABA due to control efforts (i.e. cutting and removal) but was fairly prevalent in the environs. Siberian elm occurred as trees, saplings and seedlings depending on the age of the stand. Trees of this type mimicked the cottonwood type on the imagery and the seedlings appeared similar to forbs and grassland types. Overall the signature ranged from a light green for young stands to a dark green for mature trees.

Photo Signature Examples

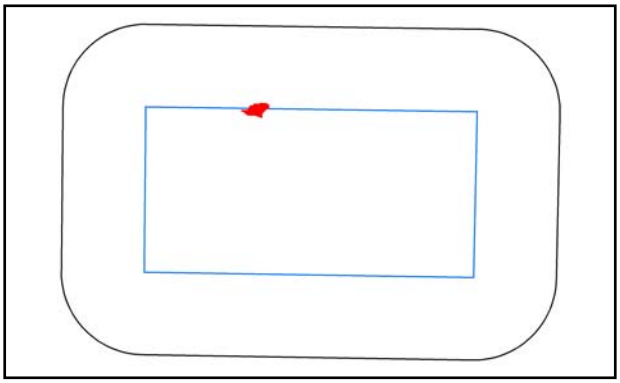
Representative Ground Photo

W-GUMB *Sideroxylon lanuginosum* Woodland Stand
Gumbully Woodland Stand

Associations and Alliances
Local Stand (no NVC Alliance at this time)

Common Species
Sideroxylon lanuginosum
Sapindus saponaria
Celtis laevigata
Chenopodium album
Elymus virginicus
Panicum capillare
Poa arachnifera

Range and Distribution



Description
This type occurred in one area along the northern boundary of WABA. It is characterized by having high cover of gumbully but other deciduous trees were also present in lesser amounts. This type contained a thick understory of grasses and forbs in openings in the canopy. This type appeared similar to the other deciduous tree types, which may have led to some confusion in the mapping. Overall the signature for this type was a light olive green with scattered gray and white patches that corresponding to the openings in the canopy.

Photo Signature Examples

Representative Ground Photo

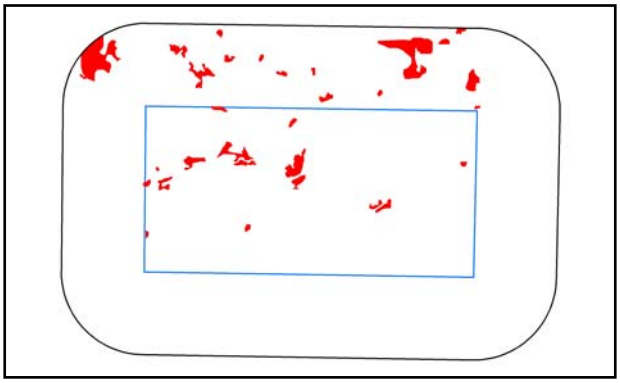
Shrublands

S-CHPM *Prunus angustifolia* Shrubland Alliance
Chickasaw Plum Shrubland Alliance

Associations and Alliances
Prunus angustifolia Shrubland Alliance

Common Species
Prunus angustifolia
Ambrosia psilostachya
Heterotheca subaxillaris
Eriogonum annuum
Cenchrus spinifex
Schizachyrium scoparium

Range and Distribution



Description
Chickasaw plum stands were fairly common at WABA occurring along the Washita River especially on the north side of the river. Smaller patches also occur throughout the central portion of the park. This type mixed with willow and other deciduous shrubs in the riparian areas and often contained very low diversity of associated species. On the imagery this type had a rough-textured appearance and ranged from bright green to tan depending on the density of the shrubs.

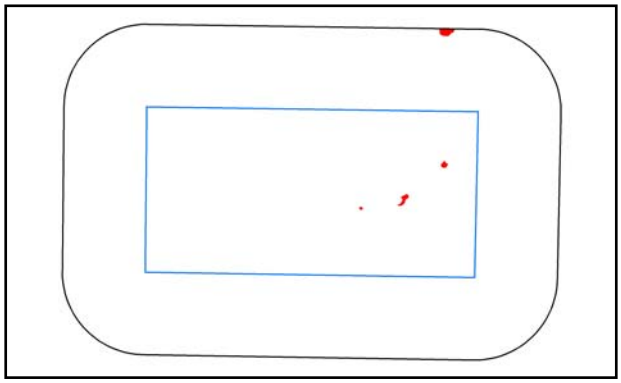
Photo Signature Examples

Representative Ground Photo

S-SMSU *Rhus glabra* Shrubland Stand
Smooth Sumac Shrubland Stand

Associations and Alliances
Local Stand (no NVC Alliance at this time)

Range and Distribution



Common Species
Rhus glabra
Celtis laevigata
Ulmus americana
Artemisia filifolia
Ambrosia psilostachya
Sorghastrum nutans

Description
This type represented only a few scattered stands of sumac present at WABA. Due to its small size this type was mapped below the minimum mapping unit and was not sampled. Sumac stands were fairly homogenous and contained little if any associated species. On the imagery this type appeared as bright green and usually occurred as circular polygons.

Representative Ground Photos

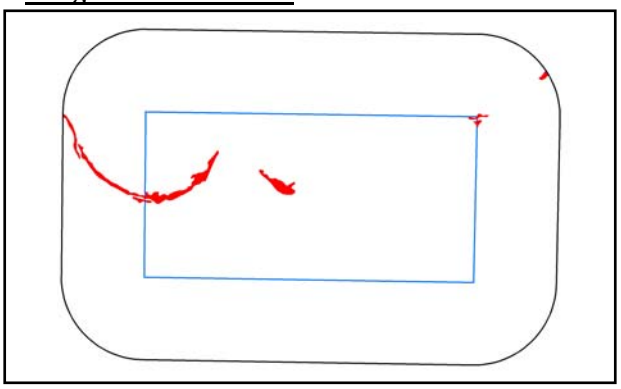
Photo Signature Examples

S-BLWL *Salix nigra* Temporarily Flooded Shrubland Alliance
Black Willow Temporarily Flooded Shrubland Alliance

Associations and Alliances
Salix nigra Temporarily Flooded Shrubland Alliance

Common Species
Salix nigra
Ulmus americana
Prunus angustifolia
Amorpha fruticosa
Panicum virgatum
Cynodon dactylon

Range and Distribution



Description
Black willow was a common riparian species at WABA often occurring in and around cottonwoods and soapberry stands. This type also intermixed with the Chickasaw plum type, which may have caused some confusion in the mapping. On the imagery this type had a light green appearance and exhibited a rough texture. Often small, individual cottonwood and elm trees were also present in polygons of this type.

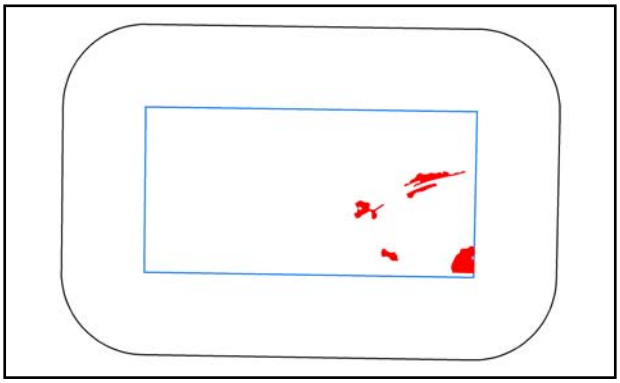
Representative Ground Photos

Photo Signature Examples

S-SSAG *Artemisia filifolia* Shrubland Alliance
Sand Sagebrush / Sand Bluestem Shrubland

Associations and Alliances
Artemisia filifolia Shrubland Alliance

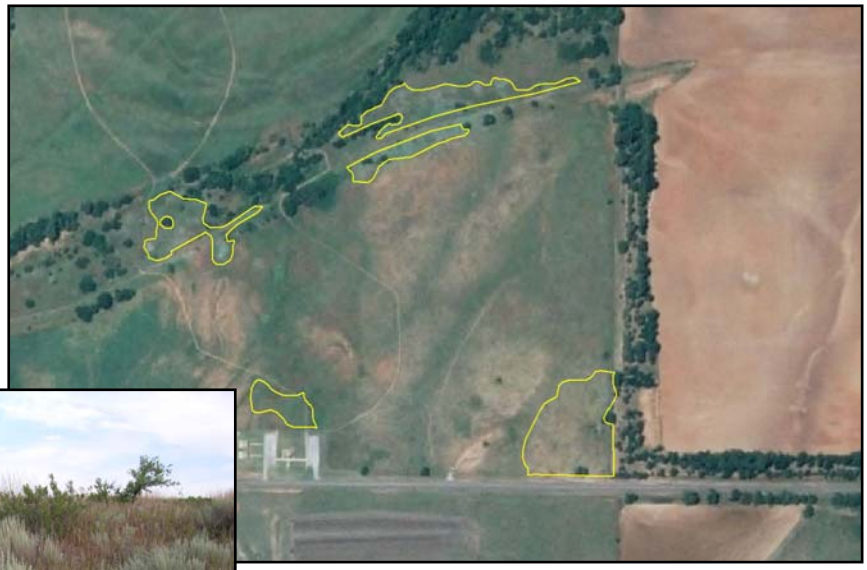
Range and Distribution



Common Species
Artemisia filifolia
Schizachyrium scoparium
Paspalum setaceum
Solanum elaeagnifolium
Pascopyrum smithii
Bromus japonicus
Ambrosia psilostachya
Artemisia ludoviciana

Description
Sand sagebrush was common to the uplands at WABA occurring primarily in the southeast corner of the park. This type often intermixed with the sand bluestem and little bluestem map units. On the imagery sand sagebrush appeared grey to white against a green or tan background created by the associated grasses and forbs present.

Photo Signature Examples



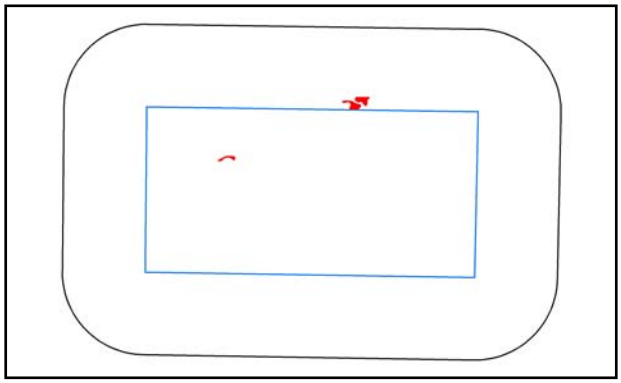
Representative Ground Photo

S-INDG *Amorpha fruticosa* Shrubland Stand
False Indigo Shrubland Stand

Associations and Alliances
Local Stand (no NVC Alliance at this time)

Common Species
Amorpha fruticosa
Ulmus americana
Salix nigra
Prunus angustifolia
Solidago gigantea
Salvia azurea
Cephalanthus occidentalis
Teucrium canadense
Schizachyrium scoparium

Range and Distribution



Description
False indigo shrub stands only occurred in three mapped patches along the Washita River. This type was fairly conspicuous in the field but appeared very similar to black willow and Chickasaw plum stands on the imagery. For that reason, this type was mapped based on its known locations. All stands were small and some were mapped below the minimum mapping unit. On the imagery this type had a rough-textured appearance and exhibited a speckled dark green signature.

Representative Ground Photos

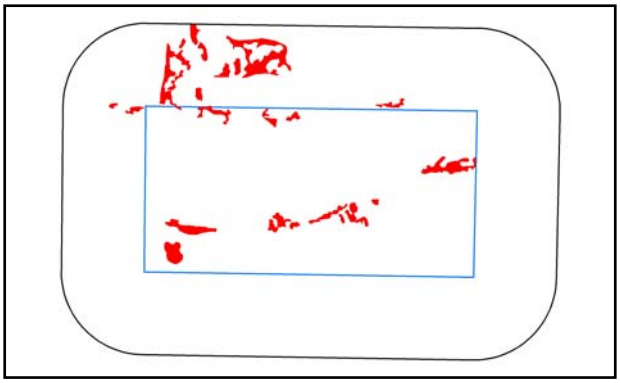
Photo Signature Examples

Herbaceous Vegetation

H-SAND *Andropogon hallii - Calamovilfa gigantea* Herbaceous Vegetation
Sand Bluestem - Big Sandreed Herbaceous Vegetation

Associations and Alliances
Andropogon hallii - Calamovilfa gigantea
Herbaceous Vegetation

Range and Distribution

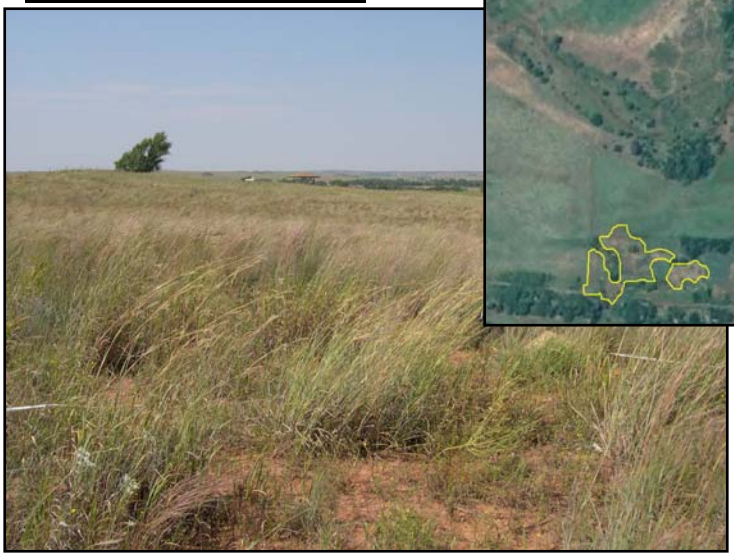


Common Species
Andropogon hallii
Schizachyrium scoparium
Bouteloua gracilis
Sporobolus cryptandrus
Artemisia filifolia
Astragalus lotiflorus
Croptilon hookerianum
Dalea enneandra
Eriogonum annuum
Heterotheca villosa
Liatris pycnostachya
Melilotus officinalis

Description
This type was fairly widespread at WABA occurring on sandy sites near the east gate and above the railroad grade. It also occurs in the central western part of the park on old sand dunes or levee crests paralleling the large northward loop of the Washita River. In the southwestern corner of the park it occurs on the contours of the low ridges that contain coarse sandy soil outcrops. This type appeared very similar to the other short and mid-grass types on the imagery. The signature for this type was a mottled gray and tan with a green tint.

Photo Signature Examples

Representative Ground Photo

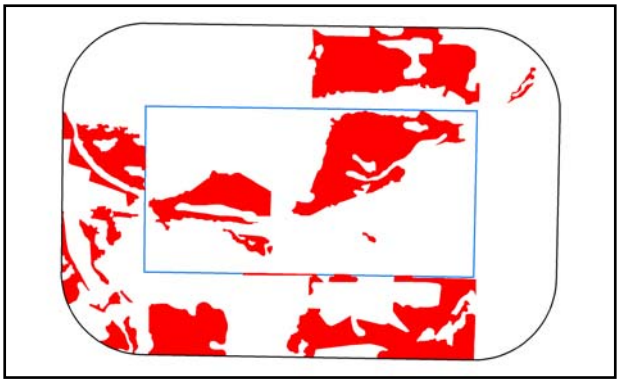


H-BIGB *Andropogon gerardii - Sorghastrum nutans* W. Great Plains Herbaceous Veg. Big Bluestem – Yellow Indiangrass W. Great Plains Herbaceous Vegetation

Associations and Alliances
Andropogon gerardii - Sorghastrum nutans Western Great Plains Herbaceous Vegetation

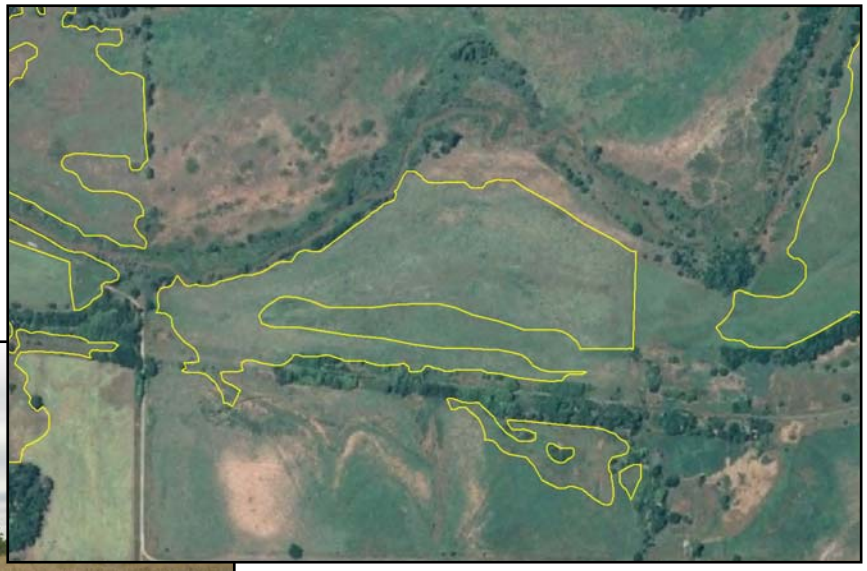
Common Species
Sorghastrum nutans
Panicum virgatum
Schizachyrium scoparium
Bouteloua curtipendula
Muhlenbergia sobolifera
Desmanthus illinoensis
Solidago gigantea
Teucrium canadense
Amorpha fruticosa

Range and Distribution



Description
This was the most common grassland type at WABA, where it represented both remnant native stands and restoration areas. Some areas of WABA only contain Indiangrass with no big bluestem. This type often occurred on many of the flat bottomlands and floodplains associated with the Washita River. On the imagery this type appeared as a mottled light green with tan and gray patches. These patches likely represented drier areas with less cover. Also dark green patches were evident in some stands likely a result of the presence of weedy forbs or individual shrubs.

Photo Signature Examples

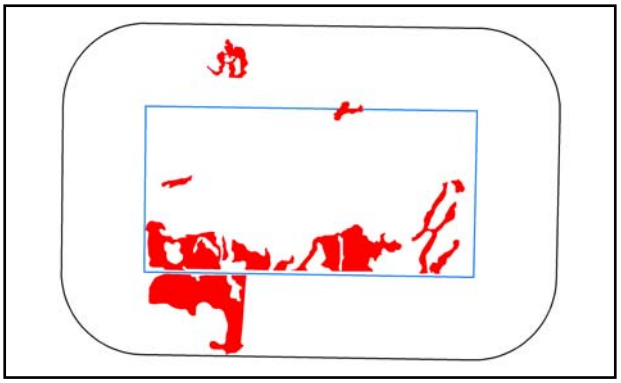


Representative Ground Photo

H-LITB *Schizachyrium scoparium - Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation
Little Bluestem - Sideoats Grama W. Great Plains Herbaceous Vegetation

Associations and Alliances
Schizachyrium scoparium - Bouteloua curtipendula
Western Great Plains Herbaceous Vegetation

Range and Distribution



Common Species
Schizachyrium scoparium
Bouteloua curtipendula
Andropogon hallii
Sorghastrum nutans
Melilotus officinalis
Ambrosia psilostachya
Grindelia papposa
Heterotheca subaxillaris
Symphyotrichum ericoides

Description
This type was common in WABA as both large fields and scattered small stands. It roughly occurred in about half of the southeast corner of the park, much of the slope north and west of the overlook, and much of the western end of the park south of the railroad grade. This type was possibly restored in some areas and often contained high cover of weedy forbs and annuals. On the imagery this type ranged in color from a characteristic smooth, bright green to a tan. The tan likely corresponded to very dry sites or areas where the grasses were dormant at the time the imagery was acquired.

Photo Signature Examples

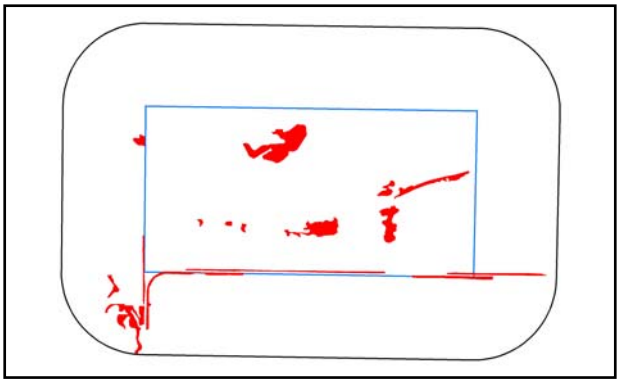
Representative Ground Photo

H-WTWG *Pascopyrum smithii* Herbaceous Alliance
Western Wheatgrass Herbaceous Alliance

Associations and Alliances
Pascopyrum smithii Herbaceous Alliance

Common Species
Pascopyrum smithii
Bromus japonicus
Panicum obtusum
Acalypha ostryifolia
Artemisia ludoviciana
Chamaesyce glyptosperma
Conyza canadensis
Mollugo verticillata
Physalis cinerascens
Solanum elaeagnifolium

Range and Distribution



Description
This type had a fairly restricted distribution at WABA and due to its small extent was only sampled with one plot. In moist areas this type tended to merge with more disturbance-oriented communities where alien species, such as Johnsongrass was common. On the imagery this type appeared similar to the other grassland types, which may have led to some confusion in the mapping. Its signature was usually bright green, although some stands on drier site appeared more gray and tan.

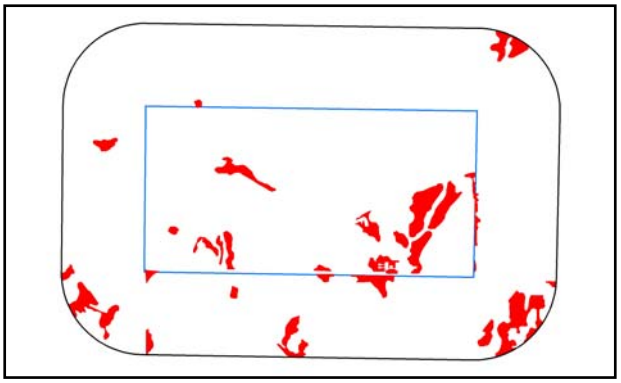
Photo Signature Examples

Representative Ground Photo

H-BLGR *Bouteloua gracilis - Bouteloua curtipendula* Herbaceous Vegetation
Blue Grama - Sideoats Grama Herbaceous Vegetation

Associations and Alliances
Bouteloua gracilis - Bouteloua curtipendula
Herbaceous Vegetation

Range and Distribution



Common Species
Bouteloua gracilis
Bouteloua curtipendula
Aristida purpurea
Schizachyrium scoparium
Mimosa borealis
Yucca glauca
Ambrosia psilostachya
Paronychia jamesii
Scutellaria resinosa
Calylophus hartwegii
Amphiachyris dracunculoides
Chamaecrista fasciculata

Description
This vegetation class was limited to dry ridge crests and shale outcrop mounds including those near the developed overlook area. This type was also used to map the maintained lawn around the overlook which contained a high amount of buffalograss (*Buchloe dactyloides*). On the imagery this type appeared mostly tan but areas with higher forb and weed cover appeared light green.

Representative Ground Photos

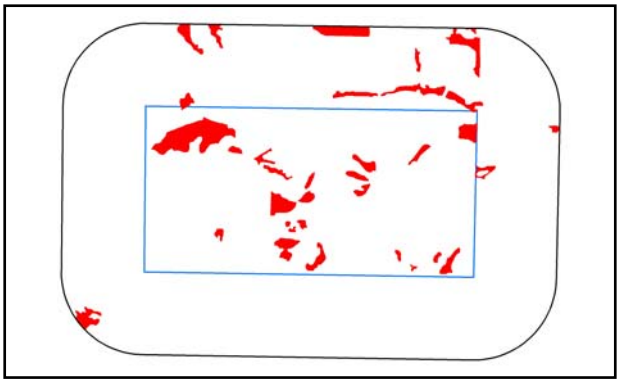
Photo Signature Examples

H-SUMP *Iva annua - (Xanthium strumarium)* Temporarily Flooded Herbaceous Sumpweed - (Cocklebur) Temporarily Flooded Herbaceous Vegetation

Associations and Alliances
Iva annua - (Xanthium strumarium) Temporarily Flooded Herbaceous

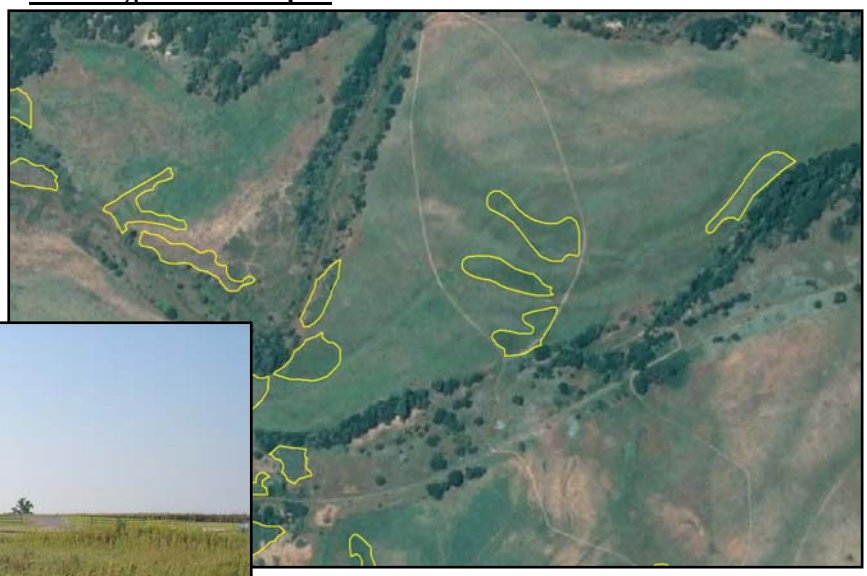
Common Species
Bromus japonicus
Bromus tectorum
Panicum capillare
Sorghastrum nutans
Ambrosia psilostachya
Ambrosia trifida
Conyza canadensis
Grindelia papposa
Helianthus annuus
Heterotheca subaxillaris
Iva annua

Range and Distribution



Description
This type represents the very weedy, annual vegetation that occurs as scattered patches throughout WABA. This type is likely in an early successional state that is similar to the cheatgrass type. However this type is not dominated by cheatgrass but rather as a mix of annual forbs that varies in composition due to soil type, moisture levels and the seedbank. On the imagery this type appeared dark green when the forbs were lush and tan on drier sites. The signature for this type was similar to the grassland types and was mapped partially on the ground from its known locations.

Photo Signature Examples

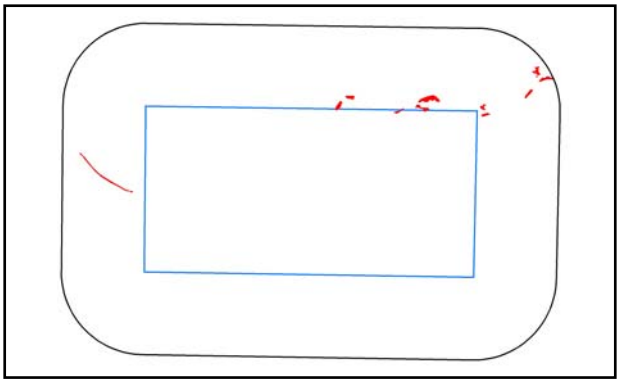


Representative Ground Photo

H-THSQ *Schoenoplectus pungens - Paspalum distichum* Herbaceous Vegetation Threesquare - Joint Crowngrass Herbaeous Vegetation

Associations and Alliances
Schoenoplectus pungens - Paspalum distichum
Herbaceous Vegetation

Range and Distribution



Common Species
Echinochloa crus-galli
Panicum virgatum
Paspalum distichum
Schoenoplectus pungens
Panicum capillare
Cyperus odoratus
Eleocharis montevidensis
Fimbristylis vahlii
Leersia oryzoides
Pluchea carolinensis
Polygonum lapathifolium
Xanthium strumarium
Iva annua

Description
This type was restricted to a few locations along the Washita River and was mapped primarily from observations made on the ground. Polygons of this type were small and were mapped below the minimum mapping unit. On the imagery this type was often partially masked by adjacent tree canopies. Also this type appeared somewhat similar to the switchgrass type and other pockets may have been omitted from the map. The signature for this type is tan and gray with a green tint.

Photo Signature Examples

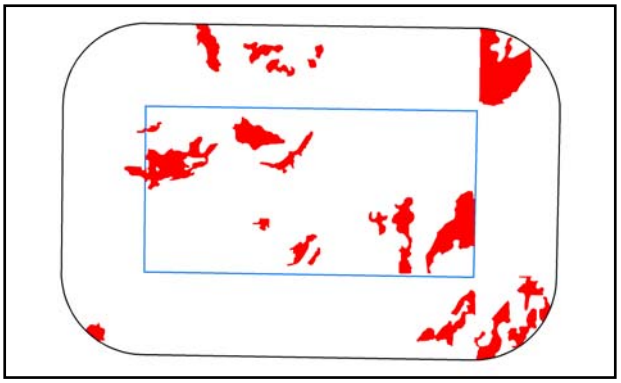
Representative Ground Photo

H-CEAT *Bromus tectorum* Semi-Natural Herbaceous Alliance
Cheatgrass Semi-Natural Herbaceous Alliance

Associations and Alliances
Bromus tectorum Semi-Natural Herbaceous Alliance

Common Species
Bromus japonicus, Bouteloua curtipendula
Bothriochloa laguroides, Pascopyrum smithii
Sporobolus spp., *Triplasis purpurea*
Ambrosia psilostachya, Artemisia filifolia
Conyza canadensis, Croptilon hookerianum
Eriogonum annuum, Grindelia papposa
Helianthus annuus, Heterotheca subaxillaris
Melilotus officinalis, Mentzelia nuda

Range and Distribution



Description
This community occurs across the eastern end and central portion of the upland in the south part of the park where it intermixes with the *Schizachyrium scoparium – Bouteloua curtipendula* Western Great Plains Herbaceous Vegetation and *Andropogon hallii – Calamovilfa gigantea* Herbaceous Vegetation. Small patches occur in isolated openings on the upper terraces along the western end of the north boundary of the park. In the floodplain it occurs on raised natural levees or old sand dunes on the north side of the Washita River in the center and western end of the park and on the south side of the river in the center of the park. This type is similar to the sumpweed type but is clearly dominated by cheatgrass and lacks the high cover of forbs. On the imagery this type appeared tan in disturbed areas and light green in more established sites.

Photo Signature Examples

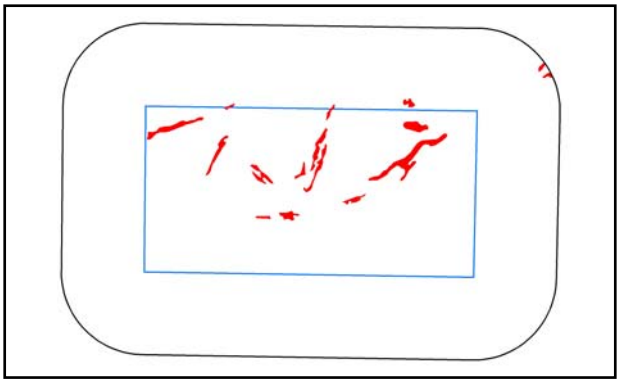
Representative Ground Photos

H-SWGR *Panicum virgatum* Temporarily Flooded Herbaceous Alliance
Switchgrass Temporarily Flooded Herbaceous Alliance

Associations and Alliances
Panicum virgatum Temporarily Flooded Herbaceous Alliance

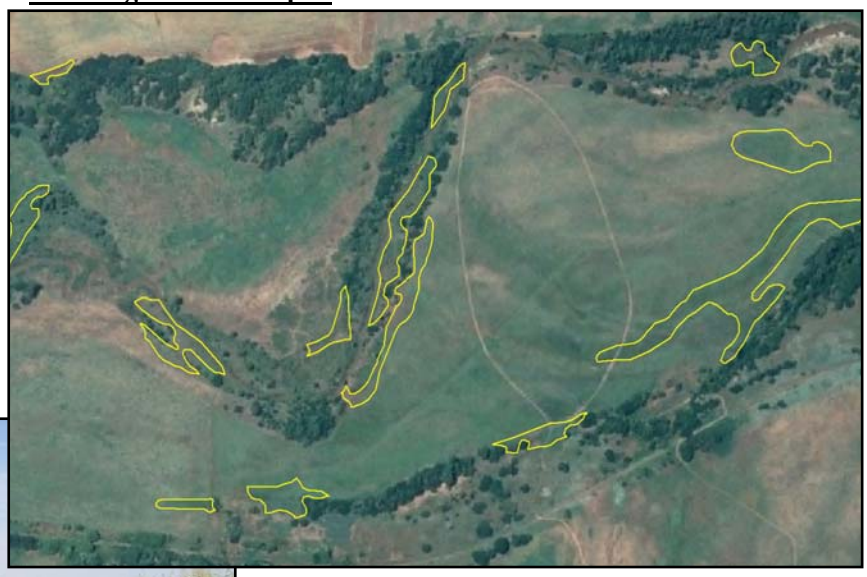
Common Species
Panicum virgatum
Sorghum halepense
Amorpha fruticosa
Chenopodium simplex
Cynodon dactylon
Sporobolus compositus
Desmanthus illinoensis
Sorghastrum nutans

Range and Distribution



Description
This type was common in swales, drainages and other low places in the park. Switchgrass was also prevalent in the riparian corridor of the Washita River and its old channels. On the imagery this type appeared bright green and was partially delineated based on its topographic position and its characteristic long, linear shape.

Photo Signature Examples



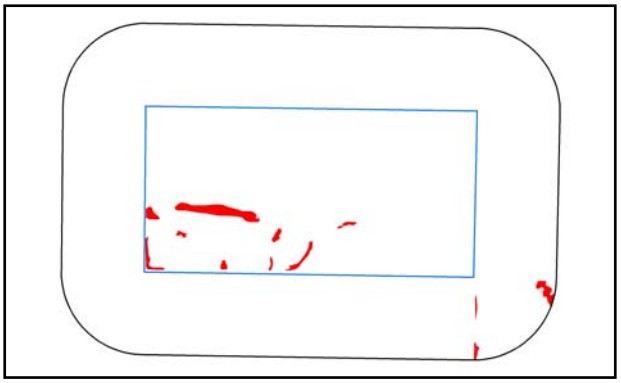
Representative Ground Photos

H-JOHN *Sorghum halepense* Herbaceous Alliance
Johnsongrass Herbaceous Alliance

Associations and Alliances
Sorghum halepense Herbaceous Alliance

Common Species
Artemisia ludoviciana
Sorghum halepense
Cynodon dactylon
Panicum virgatum
Amorpha fruticosa
Prunus angustifolia
Helianthus annuus
Schizachyrium scoparium
Kochia scoparia
Andropogon hallii

Range and Distribution



Description
This type represents areas dominated by Johnsongrass and primarily other non-native species. On moist sites this type formed dense, lush stands that were over 1 meter tall. On the imagery this type appeared both as dark green grasslands and lighter green to tan on drier areas. This type had a similar signature to other grasslands and some confusion may have occurred in the mapping of these types.

Photo Signature Examples

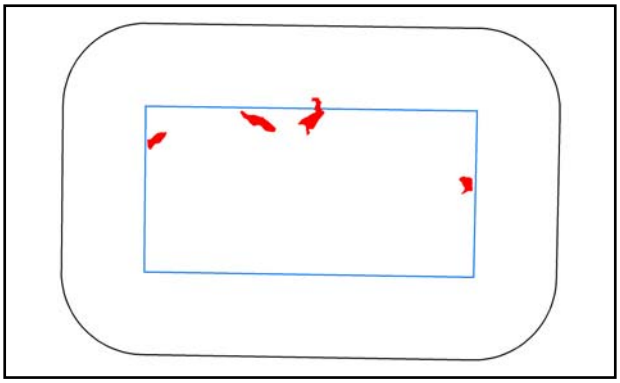
Representative Ground Photos

H-BERM *Cynodon dactylon* Herbaceous Alliance
Bermuda Grass Herbaceous Alliance

Associations and Alliances
Cynodon dactylon Herbaceous Alliance

Common Species
Cynodon dactylon
Chenopodium album
Sorghum halepense
Tridens flavus
Setaria parviflora
Bromus japonicus
Panicum virgatum
Ambrosia psilostachya
Helianthus annuus
Sporobolus cryptandrus

Range and Distribution

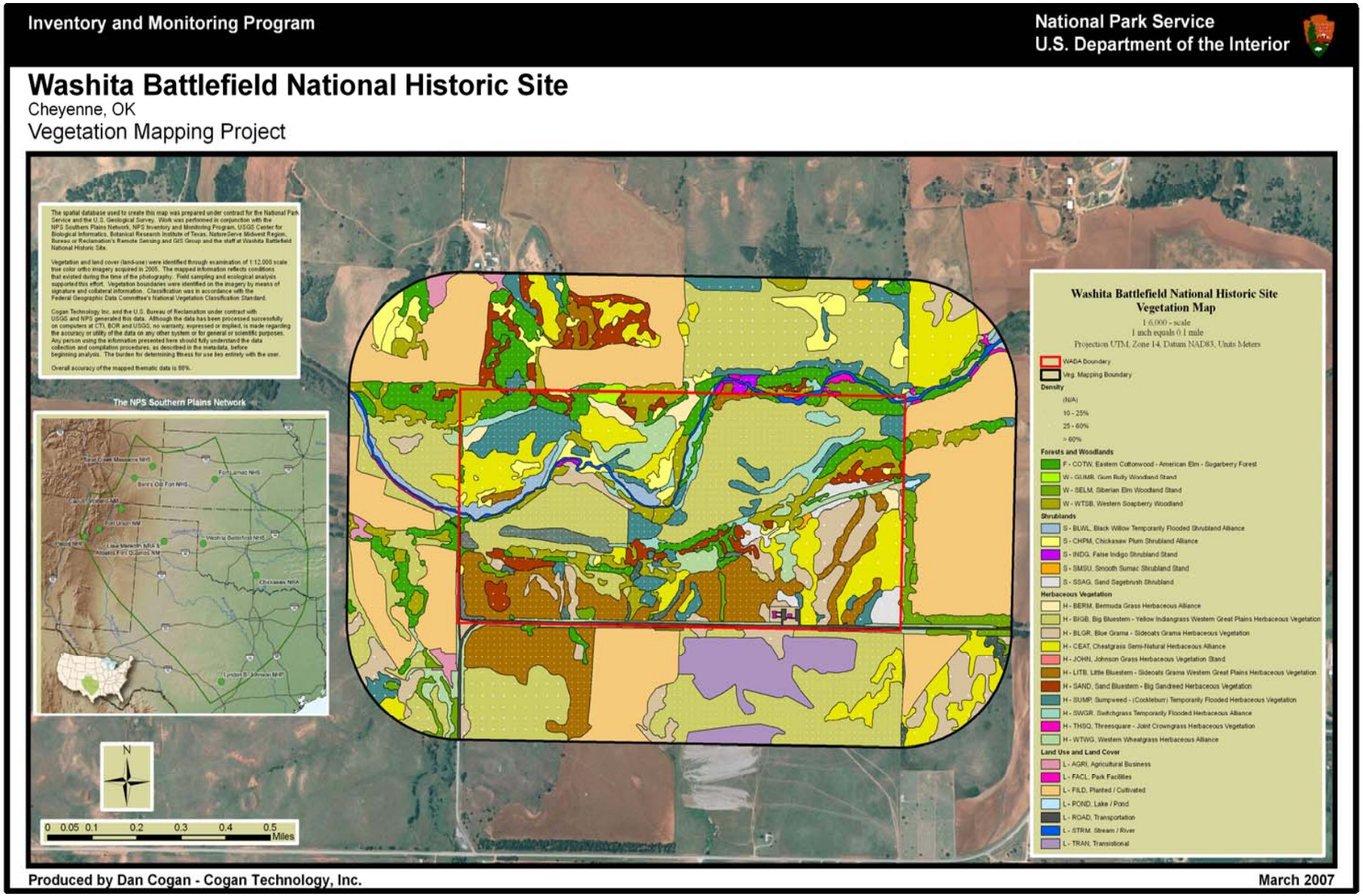


Description
This type was restricted to four areas in the park were Bermuda grass was the clear dominant. Bermuda grass also occurred as an associate with other weedy types throughout the park especially in disturbed and weedy sites. This type had many species in common with the other weedy and disturbed types and some confusion may have occurred in the mapping. On the imagery this type appeared mostly as bright green but it also exhibited a tan color on drier, more recently disturbed areas.

Photo Signature Examples

Representative Ground Photos

APPENDIX G: Final WABA Vegetation Map


Inventory and Monitoring Program
National Park Service
U.S. Department of the Interior
Washita Battlefield National Historic Site
Cheyenne, OK
Vegetation Mapping Project
The spatial database used to create this map was prepared under contract for the National Park Service and the U.S. Geological Survey. Work was performed in conjunction with the NPS Southern Plains Network, NPS Inventory and Monitoring Program, USGS Center for Biological Informatics, Botanical Research Institute of Texas, NatureServe Midwest Region, Bureau of Reclamation's Remote Sensing and GIS Group and the staff at Washita Battlefield National Historic Site.
Vegetation and land cover (land-use) were identified through examination of 1:12,000 scale true color ortho imagery acquired in 2005. The mapped information reflects conditions that existed during the time of the photography. Field sampling and ecological analysis supported this effort. Vegetation boundaries were identified on the imagery by means of signature and collateral information. Classification was in accordance with the Federal Geographic Data Committee's National Vegetation Classification Standard.
Cogan Technology Inc. and the U.S. Bureau of Reclamation under contract with USGS and NPS generated this data. Although the data has been processed successfully on computers at CTI, BOR and USGS, no warranty, expressed or implied, is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes. Any person using the information presented here should fully understand the data collection and compilation procedures, as described in the metadata, before beginning analysis. The burden for determining fitness for use lies entirely with the user.
Overall accuracy of the mapped thematic data is 89%.
The NPS Southern Plains Network
Washita Battlefield National Historic Site
Vegetation Map
1:6,000 - scale
1 inch equals 0.1 mile
Projection UTM, Zone 14, Datum NAD83, Units Meters
WABA Boundary
Veg. Mapping Boundary
Density
(N/A)
10 - 25%
25 - 60%
> 60%
Forests and Woodlands
F - COTW, Eastern Cottonwood - American Elm - Sugarberry Forest
W - GUMR, Gum Bully Woodland Stand
W - SELM, Siberian Elm Woodland Stand
W - WTSB, Western Soapberry Woodland
Shrublands
S - BLWL, Black Willow Temporarily Flooded Shrubland Alliance
S - CHPM, Chickasaw Plum Shrubland Alliance
S - INDG, False Indigo Shrubland Stand
S - SMSU, Smooth Sumac Shrubland Stand
S - SSAG, Sand Sagebrush Shrubland
Herbaceous Vegetation
H - BERM, Bermuda Grass Herbaceous Alliance
H - BIGB, Big Bluestem - Yellow Indiangrass Western Great Plains Herbaceous Vegetation
H - BLGR, Blue Grama - Sideoats Grama Herbaceous Vegetation
H - CEAT, Cheatgrass Semi-Natural Herbaceous Alliance
H - JOHN, Johnson Grass Herbaceous Vegetation Stand
H - LITB, Little Bluestem - Sideoats Grama Western Great Plains Herbaceous Vegetation
H - SAND, Sand Bluestem - Big Sandreed Herbaceous Vegetation
H - SUMP, Sumpweed - (Cocklebur) Temporarily Flooded Herbaceous Vegetation
H - SWGR, Switchgrass Temporarily Flooded Herbaceous Alliance
H - THSQ, Threesquare - Joint Crowngrass Herbaceous Vegetation
H - WTWG, Western Wheatgrass Herbaceous Alliance
Land Use and Land Cover
L - AGRI, Agricultural Business
L - FACL, Park Facilities
L - FILD, Planted / Cultivated
L - POND, Lake / Pond
L - ROAD, Transportation
L - STRM, Stream / River
L - TRAN, Transitional
N
0 0.05 0.1 0.2 0.3 0.4 0.5
Miles
Produced by Dan Cogan - Cogan Technology, Inc.
March 2007

The U.S. Department of the Interior (DOI) is the nation's principal conservation agency, charged with the mission "*to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities."* More specifically, Interior protects America's treasures for future generations, provides access to our nation's natural and cultural heritage, offers recreation opportunities, honors its trust responsibilities to American Indians and Alaska Natives and its responsibilities to island communities, conducts scientific research, provides wise stewardship of energy and mineral resources, fosters sound use of land and water resources, and conserves and protects fish and wildlife. The work that we do affects the lives of millions of people; from the family taking a vacation in one of our national parks to the children studying in one of our Indian schools.

NPS D-46, May 2007

National Park Service
U.S. Department of the Interior

Southern Plains Inventory and Monitoring Network
P.O. Box 329 (mailing)
100 Ladybird Lane (physical)
Johnson City, TX 78636

www.nps.gov

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