National Park Service
U.S. Department of the Interior

Natural Resource Program Center

# Vegetation Classification and Mapping of Tallgrass Prairie National Preserve

*Project Report*

Natural Resource Report NRR/HTLN/NRR—2011/346

**ON THE COVER**
Tallgrass prairie landscape at the Tallgrass Prairie National Preserve; view of stone school with wild rye (Elymus canadensis), wild alfalfa (Psoralidium tenuifolium), and blacksamson echinacea (Echinacea angustifolia) seedheads in the foreground.
Photograph by: Kelly Kindscher

# Vegetation Classification and Mapping of Tallgrass Prairie National Preserve

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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This report is available from http://web.ku.edu/~kindscher/tallgrass and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).
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# Contents

# Contents (continued)

# Figures

Page

# Tables

Page

# Appendices

Page

# Executive Summary

The Tallgrass Prairie National Preserve (TAPR) encompasses 10,894 acres in eastern Kansas, just north of Strong City. This park unit was created on November 12, 1996 and is the first to protect a nationally significant example of the once vast tallgrass prairie ecosystem. Of the 400,000 square miles of tallgrass prairie that once covered the North American continent, less than four percent remains, primarily in the Flint Hills. The park unit is primarily rocky upland prairies and deep-soiled prairies in the lowlands. It also contains some wet prairie ravines, riparian forests and some former cropland and restored prairie.

A three-year program was initiated to complete the task of mapping and classifying the vegetation at TAPR. The Kansas Biological Survey (KBS) in conjunction with NatureServe developed a vegetation classification using the National Vegetation Classification System and produced a digital vegetation map. To classify the vegetation, plots located throughout TAPR were sampled during the summer of 2008. Additional data were obtained from vegetation plots sampled by the Inventory & Monitoring program in 2006. Analysis of the plot data by KBS produced 12 map units (eight vegetated and four land-use) which are directly matched to corresponding plant associations and land-use classes. Descriptions and a field key for all plant communities of TAPR are included in this report. Draft maps were printed, field tested, reviewed and revised. Accuracy assessment (AA) data points were collected on 112 data points in 2009 by KBS and used to verify the map's accuracy.

# Introduction

## Tallgrass Prairie National Preserve Vegetation Mapping Project

The Tallgrass Prairie National Preserve (TAPR) Vegetation Mapping Project was organized and coordinated by the Kansas Biological Survey (KBS) at the University of Kansas, in cooperation with NatureServe, in accordance with the standards set forth by the U.S. Geological Survey (USGS) – National Park Service (NPS) Vegetation Mapping Program.

The TAPR Vegetation Mapping Project was initiated because the preserve protects a nationally significant example of the once vast tallgrass prairie ecosystem. Of the 400,000 square miles of tallgrass prairie that once covered the North American continent, less than four percent remains, primarily in the Flint Hills. Although the Tallgrass Prairie National Preserve had been mapped at a coarse level (tallgrass prairie vs. riparian forest area), a more accurate map was needed to break out grassland types, rock outcrops, replanted vegetation, water, and other landmarks to National Vegetation Classification alliance. A unified objective classification, such as outlined in the National Park Service's Vegetative Mapping Program, can become a valuable aid to the preserve for the use in vegetation management, grazing, fire, and monitoring wetlands and wildlife. Since the National Park Service is charged with conserving, protecting, and interpreting the resources of this prairie landscape, an accurate and detailed vegetation map and data layers for a GIS is very useful for management purposes.

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

## USGS-NPS Vegetation Mapping Program

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

Vegetation Mapping Program scientists developed procedures for classification, mapping, and accuracy assessment (The Nature Conservancy [TNC] and Environmental Systems Research Institute [ESRI] 1994a).

Use of the National Vegetation Classification System (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 facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as

well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs. In addition they can be used to provide a structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental conditions and ecological processes across the landscape.

The NVCS 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 and ESRI 1994a; Grossman et al. 1998). The NVCS is currently supported and endorsed by multiple federal agencies, the Federal Geographic Data Committee (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.

### *Vegetation Mapping Program Standards*

The NPS I&M Program established guidance and standards for all vegetation mapping projects in a series of documents:

*Protocols*

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

*Standards*

- National Vegetation Classification Standard (FGDC 1997);
- Spatial Data Transfer Standard (FGDC 1998b);
- Content Standard for Digital Geospatial Metadata (FGDC 1998a);
- United States National Map Accuracy Standards (USGS 1999);
- Integrated Taxonomic Information System (http://www.itis.gov/);
- program-defined standards for map attribute accuracy and minimum mapping unit.

These documents are available on the USGS-NPS Vegetation Program Web site (http://biology.usgs.gov/npsveg/standards.html).

### *Tallgrass Prairie National Preserve*

In November of 1996, federal legislation was passed creating the 10,894 acre Tallgrass Prairie National Preserve in the Flint Hills region of Kansas, located in Chase County, Kansas, outside of Strong City. Ownership of the park is a unique private/public partnership between the National Park Service and The Nature Conservancy. The preserve protects a nationally significant example of the once vast tallgrass prairie ecosystem.

Tallgrass Prairie National Preserve was created on November 12, 1996 to "…preserve, protect, and interpret for the public an example of a tallgrass prairie ecosystem…" and to "…preserve and interpret for the public the historic and cultural values represented on the Spring Hill Ranch."

The preserve is a designated National Historic Landmark that, "…outstandingly represents the transition from the open range to the enclosed holdings of the large cattle companies in the 1880's." In addition, the nomination notes that "…the ranch lands (contributing site) have retained a high

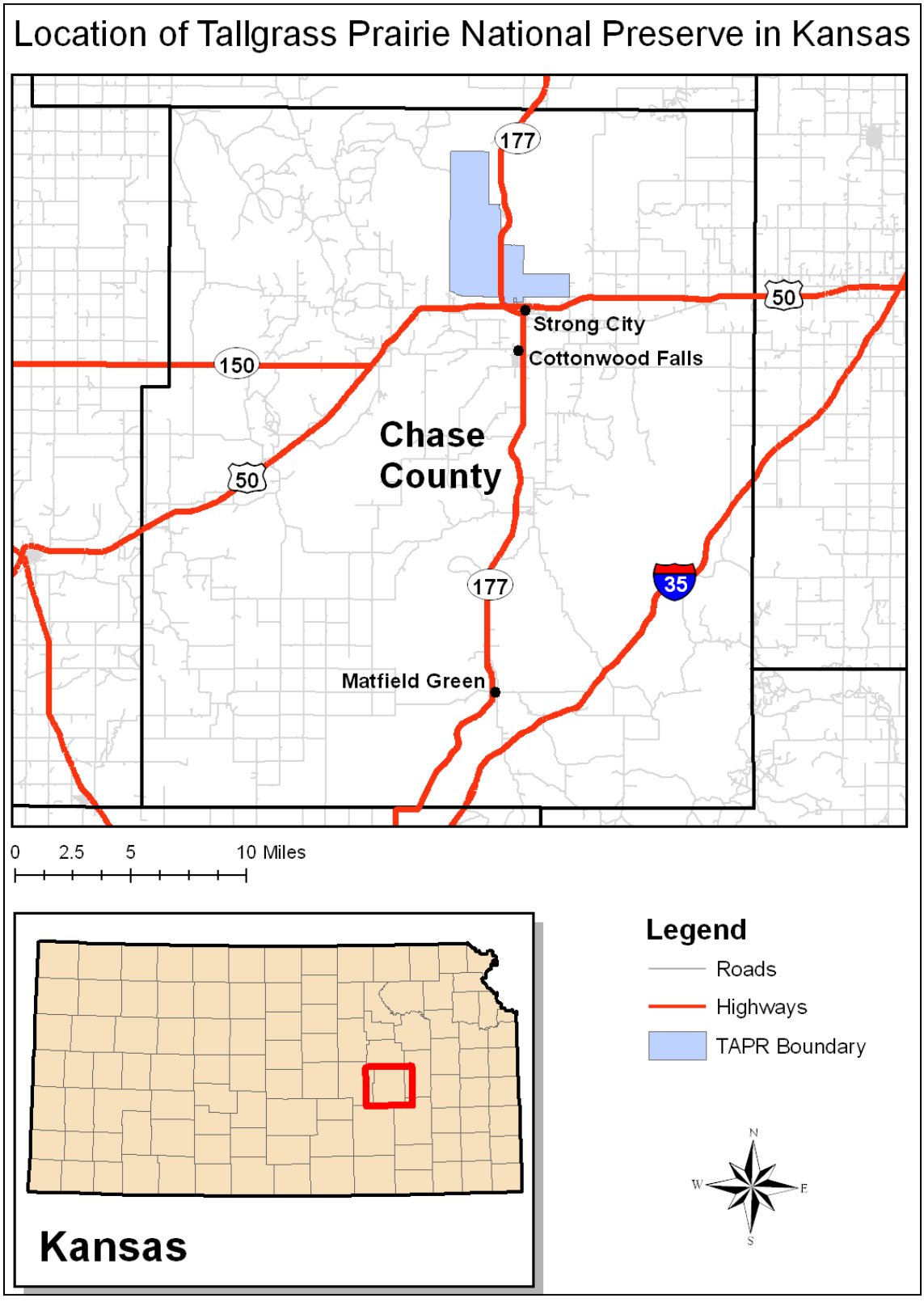


**Figure 1.** Location of Tallgrass Prairie National Preserve in Chase County, Kansas.

level of integrity in all areas of consideration: location, setting, feeling, design, materials, workmanship, as well as association" (Wolfenbarger and Nimz 1996)

The preserve was established to provide visitors access to the cultural and natural features of the Spring Hill/Z Bar Ranch. The preserve actively uses large grazers, i.e. bison and cattle, to manage the natural landscape and represent the cultural landscape.

## Project Statistics

Field Work Summers of 2008 and 2009:

Plot Sampling = 77 Plots:

54 plots sampled in July 2008 by the Kansas Biological Survey staff
23 plots sampled during the 2008 growing season by the Heartland Network

Accuracy Assessment Points = 132

112 points to assess vegetation classification
20 additional points to assess presence of seeps
All collected in July 2009 by the Kansas Biological Survey staff

Classification:

6 NVC Plant Associations
2 Park Special Vegetation Classes
4 Non-Vegetated Land-Use Classes

GIS Database 2006 – 2009:

Project Size = 18,805 acres (7610.11 hectares)

Tallgrass Prairie National Preserve = 10,894 acres (4408.65 hectares)
Environs = 7,911 acres (3201.47 hectares)

Base Imagery acquired from the NPS:

Fall 2005 IKONOS image

Ancillary Imagery acquired by the Kansas Applied Remote Sensing Program, a program of the Kansas Biological Survey:

June and September of 2008 IKONOS image
2003, 2004, 2005, 2006, and 2008 United Stated Department of Agriculture (USDA) Farm Service Agency National Agriculture Imagery Program (NAIP)
2002 and 1991 United States Geological Survey (USGS) Digital Orthophoto Quarter Quads (DOQQs)
1938 panchromatic imagery

Minimum Mapping Unit = 0.5 hectare
Total Size = 569 Polygons
Average Polygon Size = 33.0 acres (13.35 hectares)
Overall Thematic Accuracy = 92.0%
Project Completion Date: 06/30/2010

# Methods

The entire map extent is 18,730 acres, of which the park comprises 10,861 acres (Figure 2). The national standard minimum mapping unit is 0.5 ha, but some polygons, notably those of seeps or thin-soiled rocky areas, are smaller than the minimum mapping unit.

The vegetation mapping project at Tallgrass Prairie National Preserve 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 tasks, including the following:

1. Plan, gather data, and coordinate tasks;

2. Survey TAPR 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 TNC and ESRI (1994a, 1994b) and TNC et al. (1994) for the USGS-NPS Vegetation Mapping Program. These documents can be found at: http://biology.usgs.gov/npsveg.

## Planning, Data Gathering and Coordination

A scoping meeting was held in June 2007 with all project participants (Kansas Biological Survey, NatureServe, Tallgrass Prairie National Preserve staff, NPS Heartland Network staff, Homestead National Monument staff, National Park Service National Vegetation Mapping staff, and The Nature Conservancy). KBS was responsible for plot sampling and reconnaissance visits of potential community types of TAPR. KBS was also responsible for entering these data into a digital database, classifying these data, and providing a list and global descriptions for the TAPR plant associations. KBS was responsible for the imagery interpretation and creating a digital vegetation map and spatial database. NatureServe reviewed and evaluated the draft classification and wrote vegetation descriptions for all associations. KBS created a vegetation key, and conducted accuracy assessment of the vegetation map. NatureServe and TAPR staff provided logistical and technical support, and helped coordinate activities.

### *Field Survey*

The field methods used by the Kansas Natural Heritage Inventory in sampling and classifying the vegetation followed the methodology outlined by the USGS-BRD/NPS Vegetation Mapping

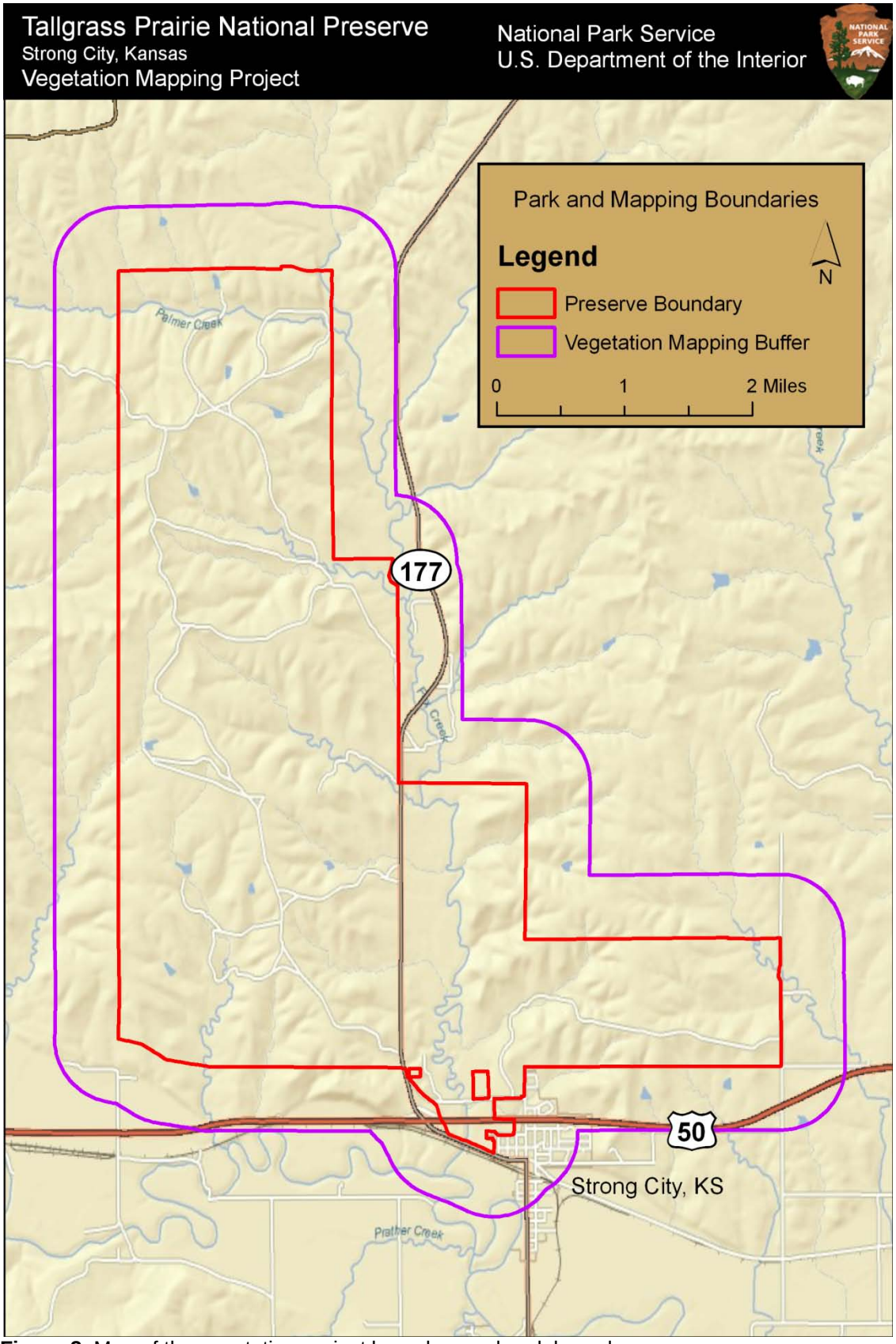


**Figure 2.** Map of the vegetation project boundary and park boundary.

Program and the NVC (Grossman et al. 1994, Grossman et al. 1998). The application of these methods to Tallgrass Prairie National Preserve is outlined below.

Vegetation data were collected in characteristic plots by KBS in July 2008 and from additional plot information acquired from the Heartland Inventory and Monitoring Network (Figure 3). Characteristic plots were located in areas that were visually representative of the preliminary vegetation categories. Plots were 100 $m^2$ in area, and GPS coordinates were recorded with a Garmin receiver. To maintain consistency with other projects in Kansas, plots were square. For a couple of the seeps in was actually necessary to make rectangular plots totaling 100$m^2$ in area due to irregular shapes of the feature. The accuracy for all of the recorded points ranged from 1-7 meters in horizontal accuracy, as recorded by the GPS receiver. Ten plots were sampled for most preliminary vegetation types: rocky mixed prairie, restored prairie, riparian vegetation, and brome fields. For "weedy" vegetation, only four characteristic plots were sampled due to the low abundance of the vegetation type. Ten plots were also sampled for springs and seeps, which were not characterized as a polygon vegetation type, but were mapped as points from Kansas Geological Survey data.

All plants found within the characteristic plots were identified to species level where possible. In a few cases, identification was only possible to the genus level (i.e., non-reproductive *Muhlenbergia* and *Carex* species). Visual estimates of percent cover were made for all species, including live material and the current year's standing dead. To maintain consistency with local vegetation surveys and other work of KBS, a continuous range of possible cover estimates was used, rather than cover classes. Plants found to cover at least one half of one percent of the plot were assigned one percent (0.01) and those with less than one half of one percent a "trace" (T). Also to maintain consistency with published accounts and similar projects in the region, species were assigned names following the Flora of the Great Plains (McGregor and Barkley 1986). An updated synonymy was completed when data were entered into the PLOTS database. Noteworthy surrounding vegetation, slopes, unusual soil features, and noticeable use by animals were also noted at each plot. Most plots were on a gentle slope with an A horizon of silty clay loam soils.

Additional plot data were obtained from the Heartland Inventory and Monitoring Network (James et al 2009). Tallgrass prairie sampling was conducted in 2008 on ten permanent plots. Each plot comprises two, 50 m long transects with ten sets of nested subplots systematically arranged. Working from the smallest to the largest plot, all herbaceous, woody shrub and tree seedling and sapling species were identified. Foliar cover was estimated in the 100 $m^2$ subplot using a modified Daubenmire (1959) scale. Forest overstory data were obtained from a breeding bird survey conducted in 2008, in which overstory trees were tallied in 18 plots (Peitz et al 2008).

### *Vegetation Classification*

Upon completion of field surveys, all recorded data were entered into the NPS PLOTS database (TNC 1997), a Microsoft Access-derived program. The PLOTS 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 Natural Resources Conservation Service in cooperation with the Biota of North America Program (USDA and NRCS 2009). Data was thoroughly proofed after entry to minimize errors.

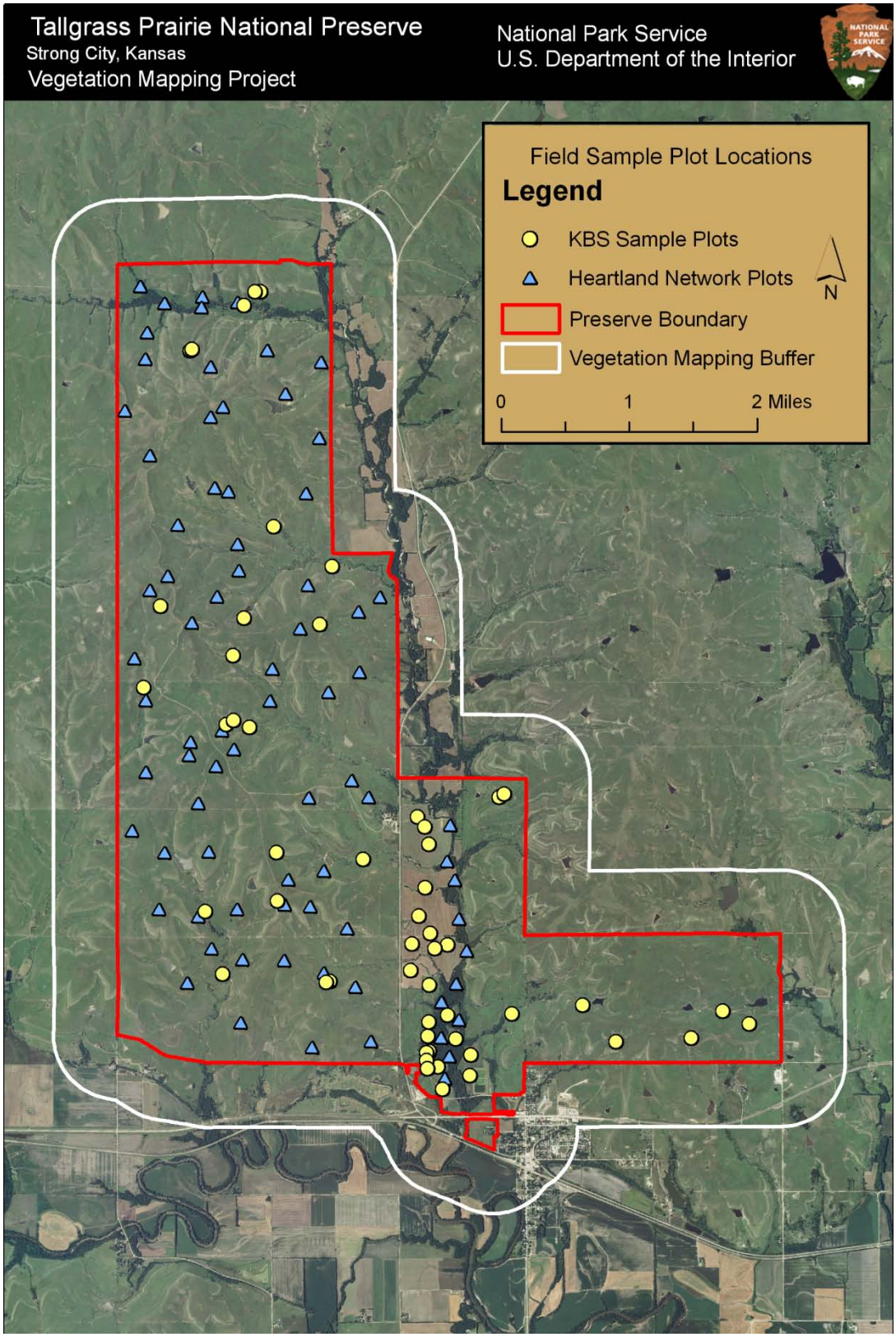


**Figure 3.** Locations of all vegetation plots collected at TAPR in 2008.

Plots were assigned to categories based on similarity of vegetation. These categories were assigned names following descriptions in Lauver et al. (1999) and NatureServe Explorer (NatureServe 2006). Where the observed TAPR vegetation did not fit descriptions of natural associations described for Kansas, semi-natural and disturbed associations or alliances described for other parks were considered. In this manner, TAPR vegetation was assigned to one of ten plant associations and alliances.

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

In the future, TAPR classification plot data will be used by NatureServe and KBS to update and improve world-wide (i.e., global) descriptions of the NVC plant associations. TAPR specific (i.e., local) descriptions were written based on TAPR plot and AA data. The final TAPR classification contains six NVC vegetation classes and two Park Special vegetation classes.

## Digital Imagery and Interpretation

The mapping component was initiated by photo interpretation and digitization of 4-band 2005 IKONOS imagery for the vegetation and land use classes determined through the field visit and expert knowledge of project team members. The heads-up digitization was performed at a display scale of 1:1500 to 1:2000. The digitization, evaluation, and modifications comprised an iterative and collaborative process involving the GIS analysts and the rest of the team. Preliminary maps were checked, corrected, and rechecked for boundary delineations.

Because land management practices, particularly grazing and burning, vegetation phenology, and moisture conditions reveal or mask target map features in the imagery, multiple image sources were used in an attempt to extract the most accurate and comprehensive feature classification possible. There was no one image that captured all vegetation communities and features at their peak differentiability. As noted above, a fall 2005 IKONOS image provided by the NPS served as the general basemap, with additional images used to check mapped features and make adjustments as needed. These image sources included 2003, 2004, 2005, 2006 (3-band, Red, Green, Blue), and 2008 (4-band, Red, Green, Blue, Near Infrared) USDA FSA NAIP, 2002 and 1991 USGS DOQQs, and 1938 panchromatic imagery. Two additional 4-band (Red, Green, Blue, Near Infrared) IKONOS scenes were acquired in June and September of 2008 specifically for this project. These IKONOS image acquisitions targeted specific phenological windows that were generally not covered by other imagery.

The 4-band imagery can be displayed as natural color (Red, Green, Blue) or color infrared imagery. Color infrared is often called false-color because the objects that are normally red appear green, green objects (except vegetation) appear blue, and "infrared" objects appear red. Because healthy green vegetation is a very strong reflector of infrared radiation, and appears bright red in color infrared imagery, it helps tremendously in vegetation mapping efforts. By using color infrared imagery, subtle differences between cool and warm season grasses, wetland vegetation and deciduous trees are apparent and can be accurately delineated.

Geologic strata data layers provided by the Kansas Geological Survey, generalized to shale and limestone, also served as a reference for indentifying zones where thin soiled tallgrass prairie might be present (Sawin, B.S. 2008).

Polygons were assigned map class number and name. The vegetation community polygons and other related and supporting data were then incorporated into a geodatabase format.

### *Accuracy Assessment*

Once the vegetation layer was finalized, the accuracy assessment (AA) was conducted. Typically in mapping exercises both thematic or attribute map accuracy and 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 and IKONOS 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).

The thematic accuracy of the vegetation map was assessed following the standards provided by the USGS-NPS National Vegetation Mapping Program's Accuracy Assessment Procedures manual (TNC et al. 1994). Assessment 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 1).

These parameters were loaded into a GIS program along with the vegetation layer. Hawth's Analysis Tools for ArcGIS (Beyer 2004) was used to pick the random target locations and also buffer them 10 meters from any polygon boundary and 50 meters 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 the authorized boundaries of TAPR due to private land access constraints.

Once the target locations were selected they were downloaded to Garmin or Trimble GPS receivers and investigators walked to the AA points to complete the assessment. During the course of the field work, the estimated position error readings on GPS receivers ranged from 1-7 meters. KBS botanists were provided with draft field maps, map unit definitions, and a key to the associations and alliances (Appendix C). In July 2009, KBS botanists traveled to 132 AA target sites and determined the vegetation association using the field key (Figure 4). At each target they recorded vegetation data on an AA form. 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 D). A rationale for the choice of dominant association was noted when the decision was not clear cut.

Twenty of these points represented springs and seeps, which are not included in the vegetation classification layer. The data recorded on the field forms were subsequently entered into the PLOTS database and reviewed for data entry errors by Kansas Natural Heritage Inventory staff. 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. However, no GPS receiver or location errors were observed.

**Table 1.** 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 |

**Table 2.** Summary of the AA statistics used at TAPR.

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

The second review step involved comparing the vegetation classification assigned by the field botanists to the vegetation classification assigned to the mapped polygon. If a mismatch was found, the mapped polygon would be corrected.

In the case of TAPR, the AA 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). All of the statistics and calculations used to analyze these data are described at length in the program manuals (TNC et al. 1994) and are summarized in Table 2. Final assessments for each point were recorded using an error matrix.

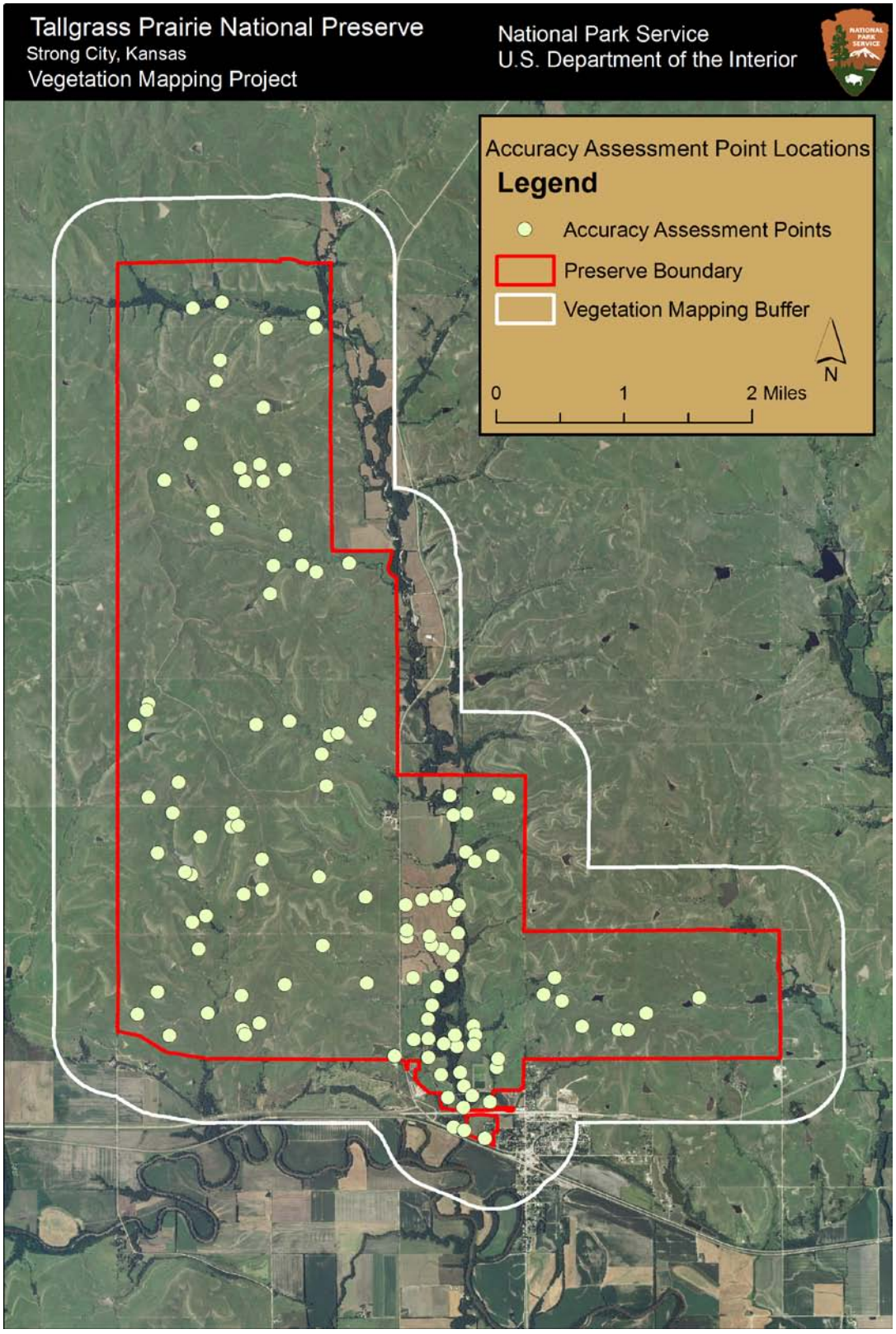


Figure 4. Locations of all accuracy assessment points collected at TAPR in 2009.

# Results

## Vegetation Classification

The final classification for TAPR resulted in eight vegetation classes, six of which had NVC descriptors. The other two classes, restored prairie and weedy vegetation, were considered park specific classifications. The classification results reflect both the moderate amount of diversity of vegetation in the park and a respectably high number of native species. During the sampling efforts a total of 322 species were recorded (Appendix E).

## Digital Imagery and Interpretation

For TAPR, 12 map units were developed and directly matched to corresponding plant associations and land-use classes (Table 3). The types included eight vegetation based map units and four land-use classes.

### *Vegetation Map*

Just over 18,800 acres including 10,894 acres in the authorized boundary of TAPR and an additional 7,911 acres in the environs were mapped using 12 map classes (Figure 5). This included four land cover classes and eight vegetation classes. Native Tallgrass Prairie (*Andropogon gerardii - Sorghastrum nutans - Schizachyrium scoparium* Flint Hills Herbaceous Vegetation) was the most abundant map unit in terms of area, covering 13,758 acres (5,568 hectares) or about 73% of the project area. In terms of frequency, Rocky Mixed Prairie (*Schizachyrium scoparium - Bouteloua curtipendula - Bouteloua gracilis* Central Plains Herbaceous Vegetation) was most abundant with 286 polygons. Frequencies for each map unit (i.e., number of polygons) and acreage per map unit are listed in Table 3.

The standard minimum mapping unit for NPS vegetation mapping projects is defined as 0.5 hectare. The average area of polygons for this project was 33.0 acres (13.4 hectares).

### *Accuracy Assessment*

The 2009 accuracy assessment effort yielded 112 points that were distributed throughout TAPR; no points were sampled in the environs due to access constraints.

During analysis of the AA points, a 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.

Examination of the final error matrix (Appendix A) shows an overall accuracy of 92.0%. Only one map class, cropland, fell below the 80% standard due to its low frequency and low sample size. Areas of confusion occurred between similar vegetation types. Confusion occurred between bur oak forest, successional forest, and wet ravine vegetation, which all had significant overlap in species and were sometimes difficult to distinguish from aerial imagery.

**Table 3.** Map units identified at TAPR, with their total frequency and acreage.

| NVC Identifier | Common Name | Scientific Name / Description | Frequency | Acres | Hectares |
|---|---|---|---|---|---|
| **Forest and Woodlands** | | | | | |
| CEGL002053 | Bur Oak Woodland | *Quercus macrocarpa / Andropogon gerardii / Hesperostipa spartea* Woodland | 28 | 509.8 | 206.3 |
| CEGL002014 | Successional Forest | *Fraxinus pennsylvanica / Ulmus* spp. / *Celtis occidentalis* Forest | 29 | 409.0 | 165.5 |
| **Herbaceous Vegetation** | | | | | |
| CEGL002201 | Native Tallgrass Prairie | *Andropogon gerardii - Sorghastrum nutans - Schizachyrium scoparium* Flint Hills Herbaceous Vegetation | 29 | 13,758.1 | 5,567.7 |
| CEGL002246 | Rocky Mixed Prairie | *Schizachyrium scoparium - Bouteloua curtipendula - Bouteloua gracilis* Central Plains Herbaceous Vegetation | 286 | 1,351.6 | 547.0 |
| CEGL002223 | Wet Ravine Vegetation | *Spartina pectinata - Eleocharis* spp. - *Carex* spp. Herbaceous Vegetation | 21 | 285.7 | 115.6 |
| (No assigned code) | Restored Prairie | Planted Semi-natural Restored Tallgrass Prairie, areas that were restored to a tallgrass prairie mix of species | 6 | 97.6 | 39.5 |
| (No assigned code) | Weedy | Areas of disturbed vegetation, former feedlot | 6 | 319.6 | 129.3 |
| CEGL005264 | Smooth Brome | *Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation | 23 | 559.4 | 226.4 |
| **Land Use/Land Cover** | | | | | |
| (No assigned code) | Cropfields | Cultivated fields | 42 | 653.8 | 264.6 |
| (No assigned code) | Developed Land | Buildings and adjacent lands | 24 | 449.8 | 182.0 |
| (No assigned code) | Ponds/Water Bodies | Man-made impoundments | 73 | 135.8 | 55.0 |
| (No assigned code) | Roadways | Highways, county roads, and rights-of-way | 2 | 274.6 | 111.1 |
| Total Land Use/Land Cover | | | 164 | 2,073.4 | 839.1 |
| Total Natural Vegetation | | | 405 | 16,731.4 | 6,771.0 |
| **Totals** | | | **569** | **18,804.8** | **7,610.0** |

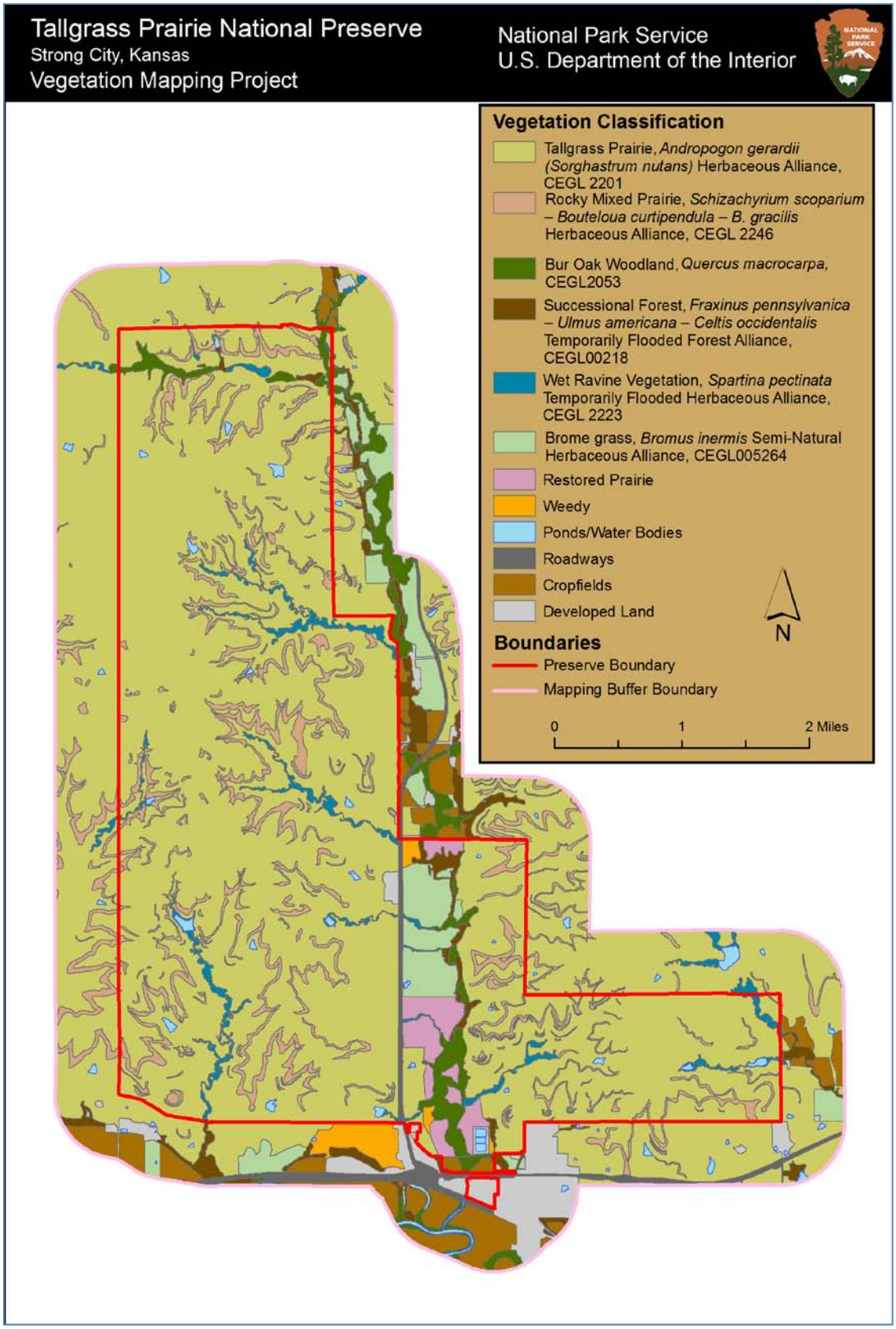


**Figure 5.** Vegetation map of Tallgrass Prairie National Preserve and environs.

# Vegetation Associations

(note additional data and explanation can be found at NatureServe, see:
http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol

***Mapped Unit Name:*** ***Bur Oak Woodland***
**Common Name:** Western Tallgrass Bur Oak Woodland
**Scientific Name:** *Quercus macrocarpa / Andropogon gerardii - Hesperostipa spartea* Woodland
Bur Oak / Big Bluestem - Porcupine Grass Woodland
**NVC Identifier:** CEGL002053

**Figure 6.** Bur Oak Woodland at Tallgrass Prairie National Preserve, July 2009.

**Global Summary:** This bur oak woodland community (Figure 6) is associated with the floodplains of rivers and streams in the central-western tallgrass region of the midwestern United States. Stands occur on gentle to steep slopes with silt or loam soils. Soils are well-drained to moderately well-drained, sometimes shallow (0-40 cm), and formed from loess or glacial till. The overstory of this community is open and dominated by *Quercus macrocarpa* (bur oak). *Quercus muehlenbergii* (chinkapin oak) can be a common associate. Shrubs are absent to common, and include *Cornus drummondii* (roughleaf dogwood), *Ceanothus herbaceus* (New Jersey tea), *Corylus americana* (American hazelnut), *Prunus americana* (American plum), *Rhus glabra* (smooth sumac), *Ribes missouriense* (Missouri gooseberry), *Symphoricarpos occidentalis* (western snowberry), and *Zanthoxylum americanum* (common pricklyash). The herbaceous

stratum can be similar to dry prairie. It includes the grasses *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem), *Sorghastrum nutans* (Indiangrass), *Sporobolus heterolepis* (prairie dropseed), and *Hesperostipa spartea* (porcupinegrass), as well as *Maianthemum stellatum* (starry false lily of the valley), *Monarda fistulosa* (wild bergamot), and *Solidago canadensis* (Canada goldenrod). In the past, periodic fires kept the canopy from closing. Where fire regimes have been disrupted, this community often begins to succeed to other, more closed oak types.

**Global Environmental Description:** This community occurs near floodplains and on gently sloping to steep upland mesic sites especially within 30 km of the Missouri River but possibly along other rivers. In Nebraska it may have been most abundant in the southeast because conditions are most suitable for tree growth there. The soils on which this community occurs are silt or loam, shallow to deep, with a pH range from 5.6-7.3. The soils of this community are moderately well-drained to well-drained. The parent material is loess or glacial till (Nelson 1987, Lauver et al. 1999, Steinauer and Rolfsmeier 2000).

**Global Vegetation Description:** The overstory of this community is open and dominated by *Quercus macrocarpa* (bur oak). *Quercus muehlenbergii* (chinkapin oak) can be a common associate. Shrubs are absent to common and include *Cornus drummondii* (roughleaf dogwood), *Ceanothus herbaceus* (New Jersey tea), *Corylus americana* (American hazelnut), *Prunus americana* (American plum), *Rhus glabra* (smooth sumac), *Ribes missouriense* (Missouri gooseberry), *Symphoricarpos occidentalis* (western snowberry), and *Zanthoxylum americanum* (common pricklyash). The herbaceous stratum can be similar to dry prairie. It includes the grasses *Andropogon gerardii* (big bluestem), *Schizachyrium scoparium* (little bluestem), *Sorghastrum nutans* (Indiangrass), *Sporobolus heterolepis* (prairie dropseed), and *Hesperostipa spartea* (porcupinegrass), as well as *Maianthemum stellatum* (starry false lily of the valley), *Monarda fistulosa* (wild bergamot), and *Solidago canadensis* (Canada goldenrod). In the past, periodic fires kept the canopy from closing. Where fire regimes have been disrupted, this community often begins to succeed to other, more closed oak types (Nelson 1987, Lauver et al. 1999, Steinauer and Rolfsmeier 2000).

Most Abundant Species:

**Table 4.** Overstory Tree Species (DBH>15 cm) within Bur Oak Woodland. (Data collected by Heartland Inventory and Monitoring Program, n=10 plots).

| Scientific Name | Common Name | Total Trees |
|---|---|---|
| Celtis occidentalis | common hackberry | 10 |
| Fraxinus americana | white ash | 3 |
| Platanus occidentalis | American sycamore | 3 |
| Carya texana | black hickory | 2 |
| Fraxinus pennsylvanica | green ash | 1 |
| Gymnocladus dioicus | Kentucky coffeetree | 1 |
| Populus deltoides | eastern cottonwood | 1 |
| Quercus macrocarpa | bur oak | 1 |
| Tilia americana | American basswood | 1 |
| Ulmus americana | American elm | 1 |
| Ulmus rubra | slippery elm | 1 |

**Global Conservation Status Rank & Reasons:** G2G3. This community has been highly degraded in the mesic sites where it occurred historically. Bur oak woodlands and forests have recently spread upslope into drier areas in the absence of fires. Sites do occur in Missouri in association with loess hill prairies, but are not tracked for conservation purposes because of low quality (M. Leahy pers. comm. 1999).

***Mapped Unit Name: Successional Forest***
**Common Name:** Central Green Ash - Elm - Hackberry Forest
**Scientific Name:** *Fraxinus pennsylvanica* - *Ulmus* spp. - *Celtis occidentalis* Forest
Green Ash - Elm species - Common Hackberry Forest
**NVC Identifier:** CEGL002014

**Figure 7**. Successional Forest at Tallgrass Prairie National Preserve, July 2009.

**Global Summary:** This community (Figure 7) is found in the central United States along upper floodplain terraces of rivers and streams and in upland ravine bottoms. Soils are moderately well-drained to poorly drained. Tree canopies are dominated by *Fraxinus pennsylvanica* (green ash), *Celtis occidentalis* (common hackberry), and *Ulmus americana* (American elm). Other tree species that may be present include *Juglans nigra* (black walnut), *Tilia americana* (American basswood), *Acer saccharinum* (silver maple), and *Populus deltoides* (eastern cottonwood). *Ulmus rubra* (slippery elm) can be part of the subcanopy. The shrub layer in the western part of the range includes *Cornus drummondii* (roughleaf dogwood), *Ribes missouriense* (Missouri gooseberry), *Symphoricarpos occidentalis* (western snowberry), and *Zanthoxylum americanum* (common pricklyash), as well as woody vines, such as *Parthenocissus vitacea* (woodbine), *Smilax tamnoides* (bristly greenbrier), *Toxicodendron radicans* (eastern poison-ivy), and *Vitis riparia* (riverbank grape). The herbaceous layer in the western part of its range includes *Elymus virginicus* (Virginia wildrye), *Festuca subverticillata* (nodding fescue), *Galium aparine* (stickywilly), *Geum canadense* (white avens), and *Laportea canadensis* (Canadian woodnettle).

**Global Environmental Description:** Stands occur along upper floodplain terraces of rivers and streams and in upland ravine bottoms. Soils are moderately well-drained to poorly drained.

**Global Vegetation Description:** The vegetation has an open to closed tree canopy that is dominated by *Fraxinus pennsylvanica* (green ash), *Celtis occidentalis* (common hackberry), and *Ulmus americana* (American elm). Other tree species that may be present include *Juglans nigra* (black walnut), *Tilia americana* (American basswood), *Acer saccharinum* (silver maple), and *Populus deltoides* (eastern cottonwood). *Ulmus rubra* (slippery elm) can be part of the subcanopy. The shrub layer in the western part of the range includes *Cornus drummondii* (roughleaf dogwood), *Ribes missouriense* (Missouri gooseberry), *Symphoricarpos occidentalis* (western snowberry), and *Zanthoxylum americanum* (common pricklyash), as well as woody vines, such as *Parthenocissus vitacea* (woodbine), *Smilax tamnoides* (bristly greenbrier), *Toxicodendron radicans* (eastern poison-ivy), and *Vitis riparia* (riverbank grape). The herbaceous layer in the western part of the range includes *Elymus virginicus* (Virginia wildrye), *Festuca subverticillata* (nodding fescue), *Galium aparine* (stickywilly), *Geum canadense* (white avens), and *Laportea canadensis* (Canadian woodnettle) (Steinauer and Rolfsmeier 2000).

Most Abundant Species:

**Table 5.** Overstory Tree Species (DBH>15 cm) within Successional Forest. (Data collected by the Heartland Network breeding bird monitoring ( n=4 plots).

| Scientific Name | Common Name | Total Trees |
|---|---|---|
| Celtis occidentalis | common hackberry | 9 |
| Fraxinus americana | white ash | 1 |
| Robinia pseudoacacia | black locust | 1 |
| Ulmus americana | American elm | 1 |
| Ulmus rubra | slippery elm | 1 |

**Global Conservation Status Rank & Reasons:** G3G5.

***Mapped Unit Name: Native Tallgrass Prairie***
**Common Name:** Flint Hills Tallgrass Prairie
**Scientific Name:** *Andropogon gerardii - Sorghastrum nutans - Schizachyrium scoparium* Flint Hills Herbaceous Vegetation
Big Bluestem - Yellow Indiangrass - Little Bluestem Flint Hills Herbaceous Vegetation
**NVC Identifier:** CEGL002201

**Figure 8.** Native Tallgrass Prairie at Tallgrass Prairie National Preserve, July 2009.

**Global Summary:** This tallgrass prairie grassland (Figure 8) is found in the Flint Hills region of the central United States. Stands occur on shallow to deep silt, loam, and clay soils. It can be somewhat poorly drained to somewhat excessively drained. This community has a dense cover of tall grasses with a moderate to high diversity of forbs. Dominant grasses are *Andropogon gerardii* (big bluestem), *Sorghastrum nutans* (Indiangrass), and *Schizachyrium scoparium* (little bluestem). *Bouteloua curtipendula* (sideoats grama), *Panicum virgatum* (switchgrass), and *Sporobolus compositus* (composite dropseed) are common, but less abundant, members of this community. Typical forbs include *Symphyotrichum ericoides* (white heath aster), *Helianthus grosseserratus* (sawtooth sunflower), *Lespedeza capitata* (roundhead lespedeza), *Solidago* (goldenrod) spp., and *Viola pedatifida* (prairie violet). Shrubs, such as *Amorpha canescens* (leadplant), and trees are usually infrequent, but can be more common near watercourses.

**Global Environmental Description:** This community is found on shallow to deep silt, loam, and clay soils. It can be somewhat poorly drained to somewhat excessively drained. The parent material is calcareous clayey shale, limestone, cherty limestone, or interbedded limestone and clayey shale (Lauver et al. 1999).

**Global Vegetation Description:** This community has a dense cover of tall grasses with a moderate to high diversity of forbs. Dominant grasses are *Andropogon gerardii* (big bluestem), *Sorghastrum nutans* (Indiangrass), and *Schizachyrium scoparium* (little bluestem). *Bouteloua curtipendula* (sideoats grama), *Panicum virgatum* (switchgrass), and *Sporobolus compositus* (composite dropseed) are common, but less abundant, members of this community. Typical forbs include *Symphyotrichum ericoides* (white heath aster), *Helianthus grosseserratus* (sawtooth sunflower), *Lespedeza capitata* (roundhead lespedeza), *Psoralidium tenuiflorum* (slimflower scurfpea), *Solidago* (goldenrod) spp., and *Viola pedatifida* (prairie violet). Shrubs, such as *Amorpha canescens* (leadplant), and trees are usually infrequent, but can be more common near watercourses (Lauver et al. 1999).
Most Abundant Species:

**Table 6.** Average percent cover of the top twenty most common species in plots within Native Tallgrass Prairie. (Data collected by the Heartland Network in 2008, n=23 plots.)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Schizachyrium scoparium* | little bluestem | 23.83 |
| *Andropogon gerardii* | big bluestem | 12.25 |
| *Sorghastrum nutans* | Indiangrass | 9.04 |
| *Amphiachyris dracunculoides* | prairie broomweed | 6.22 |
| *Sporobolus compositus* | composite dropseed | 3.13 |
| *Buchloe dactyloides* | buffalograss | 2.93 |
| *Panicum virgatum* | switchgrass | 2.57 |
| *Bouteloua curtipendula* | sideoats grama | 2.09 |
| *Carex spp.* | sedge | 1.83 |
| *Ambrosia psilostachya* | Cuman ragweed | 1.72 |
| *Artemisia ludoviciana* | white sagebrush | 1.55 |
| *Lespedeza violacea* | violet lespedeza | 0.92 |
| *Oxalis spp.* | woodsorrel | 0.86 |
| *Bouteloua hirsuta* | hairy grama | 0.86 |
| *Oxalis violacea* | violet woodsorrel | 0.82 |
| *Bouteloua gracilis* | blue grama | 0.75 |
| *Callirhoe alcaeoides* | light poppymallow | 0.73 |
| *Dichanthelium spp.* | rosette grass | 0.67 |
| *Panicum capillare* | witchgrass | 0.62 |

**Global Conservation Status Rank & Reasons:** G4.

***Mapped Unit Name: Rocky Mixed Prairie***

**Common Name:** Central Great Plains Little Bluestem Prairie

**Scientific Name:** *Schizachyrium scoparium - Bouteloua curtipendula - Bouteloua gracilis* Central Plains Herbaceous Vegetation
Little Bluestem - Sideoats Grama - Blue Grama Central Plains Herbaceous Vegetation

**NVC Identifier:** CEGL 002246

**Figure 9.** Rocky Mixed Prairie at Tallgrass Prairie National Preserve, July 2009.

**Global Summary:** This little bluestem - sideoats grama grassland community (Figure 9) is found in the south-central Great Plains of the United States. Stands occur on level to moderately sloping uplands, but are more likely to be on steep ravine slopes. The loam, clay loam, silty loam, or silty soils are usually formed over limestone. They are shallow to moderately deep, well-drained, and usually contain a substantial amount of rock fragments. The vegetation often forms two layers, a shorter layer of grasses and a taller layer of mixed grasses and forbs. Cover is moderately dense to dense in most stands. The vegetation is characteristically dominated by three species, *Schizachyrium scoparium* (little bluestem), *Bouteloua curtipendula* (sideoats grama), and *Bouteloua gracilis* (blue grama). The first two are mid grasses and the latter is a short grass. *Schizachyrium scoparium* (little bluestem) is often the tallest dominant grass, reaching 0.5-0.8 m in Oklahoma. *Andropogon gerardii* (big bluestem), *Sporobolus cryptandrus* (sand dropseed), and *Sorghastrum nutans* (Indiangrass) are present, especially on lower slopes. The short grasses *Buchloe dactyloides* (buffalograss) and *Bouteloua hirsuta* (hairy grama) grow on upper slopes and level ground. Forbs include *Ambrosia psilostachya* (Cuman ragweed),

*Dalea enneandra* (nineanther prairie clover), *Echinacea angustifolia* (blacksamson echinacea), *Liatris punctata* (dotted blazing star), *Calylophus serrulatus* (yellow sundrops), and *Psoralidium tenuiflorum* (slimflower scurfpea).

**Global Environmental Description:** This community is primarily found on level to moderately sloping uplands, but is more likely to be on steep ravine slopes in western Kansas (Kuchler 1974). The loam, clay loam, silty loam, or silty soils usually formed over limestone. They are shallow to moderately deep, well-drained, and usually contain a substantial amount of rock fragments (Heitschmidt et al. 1970, Johnston 1987).

**Global Vegetation Description:** The vegetation in this community often forms two layers, a shorter layer of grasses and a taller layer of mixed grasses and forbs (Kuchler 1974). Cover is moderately dense to dense in most stands (Weaver and Albertson 1956). The vegetation is characteristically dominated by three species, *Schizachyrium scoparium* (little bluestem), *Bouteloua curtipendula* (sideoats grama), and *Bouteloua gracilis* (blue grama). The first two are mid grasses and the latter is a short grass. *Schizachyrium scoparium* (little bluestem) is often the tallest dominant grass, reaching 0.5-0.8 m in Oklahoma (Bruner 1931). *Andropogon gerardii* (big bluestem), *Sporobolus cryptandrus* (sand dropseed), and *Sorghastrum nutans* (Indiangrass) are present, especially on lower slopes. The short grasses *Buchloe dactyloides* (buffalograss) and *Bouteloua hirsuta* (hairy grama) grow on upper slopes and level ground. Forbs include *Ambrosia psilostachya* (Cuman ragweed), *Dalea enneandra* (nineanther prairie clover), *Echinacea angustifolia* (blacksamson echinacea), *Liatris punctata* (dotted blazing star), *Calylophus serrulatus* (yellow sundrops), and *Psoralidium tenuiflorum* (slimflower scurfpea).

Most Abundant Species:

**Table 7.** Average percent cover of the top twenty most common species in plots within Rocky Mixed Prairie. (Data collected by KBS in 2008, n=10 plots.)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Andropogon gerardii* | big bluestem | 40.50 |
| *Bouteloua hirsuta* | hairy grama | 5.90 |
| *Bouteloua curtipendula* | sideoats grama | 4.21 |
| *Amorpha canescens* | leadplant | 3.40 |
| *Schizachyrium scoparium* | little bluestem | 2.41 |
| *Panicum virgatum* | switchgrass | 2.20 |
| *Dalea purpurea* | purple prairie clover | 2.14 |
| *Rhus glabra* | smooth sumac | 1.80 |
| *Psoralidium tenuiflorum* | slimflower scurfpea | 1.71 |
| *Sorghastrum nutans* | Indiangrass | 1.61 |
| *Vernonia baldwinii* | Baldwin's ironweed | 1.32 |
| *Ambrosia psilostachya* | Cuman ragweed | 1.03 |
| *Euthamia gymnospermoides* | Texas goldentop | 1.03 |
| *Artemisia ludoviciana* | white sagebrush | 0.32 |
| *Sporobolus compositus* | composite dropseed | 0.32 |
| *Tragia betonicifolia* | betonyleaf noseburn | 0.32 |
| *Baptisia australis* | blue wild indigo | 0.20 |
| *Monarda fistulosa* | wild bergamot | 0.20 |
| *Croton monanthogynus* | prairie tea | 0.14 |

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Hymenopappus scabiosaeus* | Carolina woollywhite | 0.13 |

**Global Rank & Reasons:** G2G4. The total number of occurrences is unknown. Seven have been documented in Kansas, where the community is ranked S2(?). Although no other occurrences have been documented, the community is also reported in Oklahoma (S?), where it may be more common.

***Mapped Unit Name: Wet Ravine Vegetation***
**Common Name:** Southern Great Plains Cordgrass Wet Prairie
**Scientific Name:** *Spartina pectinata* - *Eleocharis* spp. - *Carex* spp. Herbaceous Vegetation
Prairie Cordgrass - Spikerush species - Sedge species Herbaceous Vegetation
**NVC Identifier:** CEGL002223

**Figure 10.** Wet Ravine at Tallgrass Prairie National Preserve, July 2009.

**Global Summary:** This wet grassland community (Figure 10) is found in the southern Great Plains on deep, poorly drained soils on level to nearly level sites near lakes, seeps, or alluvial lowlands. The soils are usually inundated for short periods during the year but may be saturated for much of the growing season. In northeastern, central, and western Oklahoma (i.e., excluding the Coastal Plain and the Oklahoma panhandle), this association occurs in floodplains, backswamps, and lake margins. This community is characterized by tall, dense graminoids with moderate forb diversity and few woody species. The dominant species, *Spartina pectinata* (prairie cordgrass), can form near monocultures in some locations. Common species include *Carex annectens* (yellowfruit sedge), *Carex blanda* (eastern woodland sedge), *Eleocharis* (spikerush) spp., *Juncus interior* (inland rush), *Juncus torreyi* (Torrey's rush), *Panicum virgatum* (switchgrass), *Rumex altissimus* (pale dock), and *Verbena hastata* (swamp verbena). Other characteristic species in Oklahoma include *Ammannia coccinea* (valley redstem), *Paspalum laeve* (field paspalum), *Pluchea odorata* (sweetscent), and *Vernonia baldwinii* (Baldwin's ironweed), and in Kansas include *Asclepias incarnata* (swamp milkweed), *Symphyotrichum*

*lanceolatum* (white panicle aster), *Baptisia alba var. macrophylla* (largeleaf wild indigo), *Helianthus grosseserratus* (sawtooth sunflower), and *Scirpus atrovirens* (green bulrush).

**Global Environmental Description:** This community is found on deep, poorly drained soils on level to nearly level sites near lakes, seeps, or alluvial lowlands (Kuchler 1974, Johnson and Knapp 1995). The soils are usually inundated for short periods during the year, but may be saturated for much of the growing season.

**Global Vegetation Description:** This community is characterized by tall, dense graminoids with moderate forb diversity and few woody species. The dominant species, *Spartina pectinata* (prairie cordgrass), can form near monocultures in some locations (Johnson and Knapp 1995). Other common species include *Carex annectens* (yellowfruit sedge), *Carex blanda* (eastern woodland sedge), *Eleocharis* (spikerush) spp., *Juncus interior* (inland rush), *Juncus torreyi* (Torrey's rush), *Panicum virgatum* (switchgrass), *Rumex altissimus* (pale dock), and *Verbena hastata* (swamp verbena). Other characteristic species in Oklahoma include *Ammannia coccinea* (valley redstem), *Paspalum laeve* (field paspalum), *Pluchea odorata* (sweetscent), and *Vernonia baldwinii* (Baldwin's ironweed), and in Kansas include *Asclepias incarnata* (swamp milkweed), *Symphyotrichum lanceolatum* (white panicle aster), *Baptisia alba var. macrophylla* (largeleaf wild indigo), *Helianthus grosseserratus* (sawtooth sunflower), and *Scirpus atrovirens* (green bulrush) (Lauver et al. 1999).

Most Abundant Species:

**Table 8.** Average percent cover of the top twenty most common species in plots within Wet Ravines. (Data collected by KBS in 2008, n=10 plots; note many areas have woody encroachment)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Bromus japonicus* | field brome | 32.31 |
| *Amorpha fruticosa* | desert false indigo | 23.80 |
| *Andropogon gerardii* | big bluestem | 12.90 |
| *Vernonia baldwinii* | Baldwin's ironweed | 8.32 |
| *Paspalum pubiflorum* | hairyseed paspalum | 8.30 |
| *Xanthium strumarium* | rough cocklebur | 7.61 |
| *Ambrosia psilostachya* | Cuman ragweed | 6.02 |
| *Sporobolus compositus* | composite dropseed | 5.31 |
| *Panicum virgatum* | switchgrass | 3.91 |
| *Ambrosia trifida* | great ragweed | 3.01 |
| *Muhlenbergia sp.* | muhly | 2.51 |
| *Solidago canadensis* | Canada goldenrod | 2.21 |
| *Sorghastrum nutans* | Indiangrass | 1.80 |
| *Teucrium canadense* | Canada germander | 1.80 |
| *Spartina pectinata* | prairie cordgrass | 1.60 |
| *Glycyrrhiza lepidota* | American licorice | 1.50 |
| *Leersia oryzoides* | rice cutgrass | 1.50 |
| *Symphoricarpos orbiculatus* | coralberry | 1.41 |
| *Tripsacum dactyloides* | eastern gamagrass | 1.21 |
| *Euthamia gymnospermoides* | Texas goldentop | 1.11 |

**Global Conservation Status Rank & Reasons:** G2G4. There are probably more than 20 occurrences rangewide. Six have been documented in Kansas, where the community is ranked SU. Although no other occurrences have been documented, the community is also reported in Oklahoma (S2). It occurs in four ecoregional subsections and has moderately restrictive environmental requirements.

***Mapped Unit Name: Wet Ravine Vegetation - Seeps and Springs***
**Common Name:** Southern Great Plains Cordgrass Wet Prairie
**Scientific Name:** *Spartina pectinata* - *Eleocharis* spp. - *Carex* spp. Herbaceous Vegetation
Prairie Cordgrass - Spikerush species - Sedge species Herbaceous Vegetation
**NVC Identifier:** CEGL002223

**Note:** Seeps (Figure 11) and springs were surveyed separately from wet ravines, although they are included within the same community type. Seeps and springs were mapped as point locations, acquired from the Kansas Geological Survey and were not mapped as polygons.

**Figure 11.** Seep at Tallgrass Prairie National Preserve, July 2009. Darker green in midground is *Eleocharis spp.,* tall seedheads are *Scirpus pendulus,* and dark brown seedheads in foreground and background are *Rumex spp.*

**Table 9**. Average percent cover of the top twenty most common species in plots within Seeps and Springs. (Data collected by KBS in 2008, n=10 plots.)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Eleocharis spp.* | spikerush | 19.31 |
| *Leersia oryzoides* | rice cutgrass | 14.40 |
| *Spartina pectinata* | prairie cordgrass | 13.00 |
| *Scirpus pendulus* | rufous bulrush | 12.40 |
| *Scirpus atrovirens* | green bulrush | 10.01 |
| *Carex spp.* | sedge | 8.51 |
| *Rorippa nasturtium-aquaticum* | watercress | 8.01 |
| *Juncus torreyi* | Torrey's rush | 7.92 |
| *Panicum virgatum* | switchgrass | 3.11 |
| *Ambrosia psilostachya* | Cuman ragweed | 2.53 |
| *Agrimonia parviflora* | harvestlice | 1.50 |
| *Cyperus setigerus* | lean flatsedge | 1.50 |
| *Amorpha fruticosa* | desert false indigo | 1.20 |
| *Glyceria striata* | fowl mannagrass | 1.11 |
| *Ambrosia artemisiifolia* | annual ragweed | 1.01 |
| *Andropogon gerardii* | big bluestem | 1.01 |
| *Carex frankii* | Frank's sedge | 1.01 |
| *Boehmeria cylindrica* | smallspike false nettle | 1.00 |
| *Carex annectens* | yellowfruit sedge | 0.91 |
| *Elymus virginicus* | Virginia wildrye | 0.81 |

***Mapped Unit Name: Smooth Brome***

**Common Name:** Smooth Brome Semi-natural Grassland

**Scientific Name:** *Bromus inermis - (Pascopyrum smithii)* Semi-natural Herbaceous Vegetation
Smooth Brome - (Western Wheatgrass) Semi-natural Herbaceous Vegetation

**NVC Identifier:** CEGL005264

**Global Summary:** This smooth brome grassland type occurs widely throughout the northern Great Plains, in disturbed montane meadows in the Rocky Mountains, on relatively mesic sites in the semi-arid interior western United States, and perhaps more widely in the midwestern U.S. and Canada. Stands can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. The type is also widely planted for revegetating disturbed land, pasture and hay fields, and has escaped into a variety of habitats, including prairie, riparian grasslands, and mesic mountain meadows. The dominant grass is *Bromus inermis* (smooth brome), a naturalized species from Eurasia that forms moderately dense to dense stands that often develop into monocultures. Other weedy species such as *Cirsium arvense* (Canada thistle) and *Poa pratensis* (Kentucky bluegrass) may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie and montane meadow grasses, such as *Pascopyrum smithii* (western wheatgrass), *Deschampsia caespitosa* (tufted hairgrass), and *Hesperostipa comata* (needle-and-thread), and sparse, scattered mesic shrubs such as *Symphoricarpos* (snowberry) spp., as well as many others. However, the native species are not conspicuous enough to identify the native plant association that could occupy the site, or the stand would be typed as such.

**Global Environmental Description:** This smooth brome grassland type occurs widely throughout the northern Great Plains, on relatively mesic sites in the semi-arid interior western United States, and perhaps more widely in the midwestern U.S. and Canada. Stands can occur in a wide variety of human-disturbed habitats, including highway rights-of-way, jeep trails, etc. The type is also widely planted for revegetating disturbed land, pasture and hay fields, and has escaped into a variety of habitats, including prairie, riparian grasslands, and mesic mountain meadows. This community is found at all elevational ranges with best examples occurring on mesic alluvial terraces. *Bromus inermis* (smooth brome) grows best on moist, well-drained, finer-textured loam and clay loams, not heavy clays or sand, and does not tolerate prolonged flooding, however, it does persist quite well on well-drained sandy loam derived from granitic parent material. It also occurs in foothills and plains at lower elevations on relatively mesic sites. It occurs on poorly drained sites to rapidly drained sites with fine-textured alluvial soils derived from shale formations found in Utah. This community persists because it is rhizomatous, and once seeded, with enough moisture, will persist, regardless of elevation, soil or landform.

**Global Vegetation Description:** This association is dominated by medium-tall (0.5-1 m) graminoids. The dominant grass is *Bromus inermis* (smooth brome), a naturalized species from Eurasia that forms moderately dense to dense stands that often develop into monocultures. Other weedy species, such as *Cirsium arvense* (Canada thistle), *Poa pratensis* (Kentucky bluegrass), and other introduced forage species, may occur as well, but native species are generally less than 10% cover. Native species may include mixed-grass prairie and montane meadow grasses, such

as *Juncus balticus* (Baltic rush), *Pascopyrum smithii* (western wheatgrass), *Deschampsia caespitosa* (tufted hairgrass), and *Hesperostipa comata* (needle-and-thread), and sparse scattered mesic shrubs, such as *Artemisia tridentata ssp. wyomingensis* (Wyoming big sagebrush), *Ericameria nauseosa* (rubber rabbitbrush), and *Symphoricarpos* (snowberry) spp., and ruderal forbs, such as *Heterotheca villosa* (hairy false goldenaster), as well as many others. However, the native species are not conspicuous enough to identify the native plant association that could occupy the site, or the stand would be typed as such.

Most Abundant Species:

**Table 10.** Average percent cover of the top twenty most common species in plots within Smooth Brome Haymeadows. Note that all species other than Bromus inermis are under 3% cover. (Data collected by KBS in 2008, n=10 plots.)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Bromus inermis* | smooth brome | 96.50 |
| *Erigeron annuus* | eastern daisy fleabane | 2.61 |
| *Convolvulus arvensis* | field bindweed | 2.12 |
| *Physalis pumila* | dwarf groundcherry | 0.52 |
| *Bromus japonicus* | field brome | 0.23 |
| *Solanum carolinense* | Carolina horsenettle | 0.12 |
| *Brickellia eupatorioides* | false boneset | 0.11 |
| *Setaria pumila* | yellow foxtail | 0.11 |
| *Conyza canadensis* | Canadian horseweed | 0.02 |
| *Chamaesyce sp.* | sandmat | 0.01 |
| *Oxalis stricta* | common yellow oxalis | 0.01 |
| *Panicum capillare* | witchgrass | 0.01 |
| *Abutilon theophrasti* | velvetleaf | 0.01 |
| *Amaranthus rudis* | roughfruit amaranth | 0.01 |
| *Ambrosia artemisiifolia* | annual ragweed | 0.01 |
| *Asclepias viridis* | green antelopehorn | 0.01 |
| *Chamaesyce nutans* | eyebane | 0.01 |
| *Gleditsia triacanthos* | honeylocust | 0.01 |
| *Mirabilis nyctaginea* | heartleaf four o'clock | 0.01 |
| *Rumex altissimus* | pale dock | 0.01 |

**Global Conservation Status Rank & Reasons:** GNA (invasive) (17-Jun-1999). This is a naturalized type from Europe and Asia, widely planted for cover, pasture, and hay, and has escaped into a variety of habitats.

***Common Name:*** ***Restored Prairie***
**Scientific Name:** Planted Semi-natural Restored Tallgrass Prairie, areas that were restored to a tallgrass prairie mix of species
**NVC Identifier:** N/A

**Figure 12.** Restored Prairie at Tallgrass Prairie National Preserve, July 2008.

**Global Summary:** This community (Figure 12) has been defined for Tallgrass Prairie National Preserve. At TAPR, managers are attempting to restore former brome fields and weedy areas to tallgrass prairie. Natural vegetation of this community is found throughout the northern tallgrass prairie region of the United States and Canada.

**Environmental Description:** The fields that have been re-planted with native grasses at Tallgrass Prairie National Preserve were once plowed, and have silt-loam soils.

**Vegetation Description:** This is a grassland community with dense vegetation dominated by tall grasses 1-2 m tall. The abundance of forbs has not reached the abundance found in native Flint Hills Tallgrass Prairie. *Sorghastrum nutans* (Indiangrass) and *Bromus japonicus* (field brome) are the most abundant grasses in this community. *Conyza canadensis* (Canadian horseweed) and *Ambrosia artemisiifolia* (annual ragweed) are common forbs.

## Most Abundant Species:

**Table** 11. Average percent cover of the top twenty most common species in plots within Restored Prairies. (Data collected by KBS in 2008, n=19 plots.)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Sorghastrum nutans* | Indiangrass | 21.30 |
| *Bromus japonicus* | field brome | 19.52 |
| *Panicum virgatum* | switchgrass | 15.71 |
| *Conyza canadensis* | Canadian horseweed | 15.02 |
| *Andropogon gerardii* | big bluestem | 6.91 |
| *Tripsacum dactyloides* | eastern gamagrass | 6.11 |
| *Ambrosia artemisiifolia* | annual ragweed | 5.00 |
| *Abutilon theophrasti* | velvetleaf | 4.61 |
| *Mollugo verticillata* | green carpetweed | 4.51 |
| *Chamaesyce maculata* | spotted sandmat | 2.70 |
| *Setaria faberi* | Japanese bristlegrass | 2.60 |
| *Setaria viridis* | green bristlegrass | 1.71 |
| *Ambrosia trifida* | great ragweed | 1.70 |
| *Erigeron annuus* | eastern daisy fleabane | 1.61 |
| *Bouteloua curtipendula* | sideoats grama | 1.41 |
| *Lactuca serriola* | prickly lettuce | 1.32 |
| *Lactuca saligna* | willowleaf lettuce | 1.21 |
| *Solanum carolinense* | Carolina horsenettle | 1.21 |
| *Amaranthus palmeri* | carelessweed | 1.20 |
| *Schizachyrium scoparium* | little bluestem | 1.01 |

***Common Name:*** ***Weedy***
**Scientific Name:** Areas of disturbed vegetation, former feedlot
**NVC Identifier:** N/A

**Figure 13.** Weedy area at Tallgrass Prairie National Preserve, July 2008.

**Global Summary and Environmental Description:** This community (Figure 13) has been defined for Tallgrass Prairie National Preserve. At TAPR, these are fields that were formerly plowed or used as feedlots, and have not yet been restored to Flint Hills Tallgrass Prairie.

**Vegetation Description:** This is a grassland community with dense vegetation dominated by tall grasses 1-2 m tall. Exotic grasses, *Bromus inermis* (smooth brome) and *Bromus japonicus* (field brome), are the most abundant grasses in this community. *Convolvulus arvensis* (field bindweed) and *Erigeron annuus* (eastern daisy fleabane) are common forbs.

## Most Abundant Species:

**Table 12.** Average percent cover of the top nineteen most common species in plots within Weedy Areas. (Data collected by KBS in 2008, n=4 plots.)

| Scientific Name | Common Name | Average % Cover |
|---|---|---|
| *Bromus inermis* | smooth brome | 32.50 |
| *Bromus japonicus* | field brome | 31.26 |
| *Convolvulus arvensis* | field bindweed | 20.75 |
| *Ambrosia trifida* | great ragweed | 15.00 |
| *Conyza canadensis* | Canadian horseweed | 7.75 |
| *Erigeron annuus* | eastern daisy fleabane | 6.25 |
| *Kochia scoparia* | burningbush | 6.25 |
| *Rumex crispus* | curly dock | 3.25 |
| *Mirabilis nyctaginea* | heartleaf four o'clock | 2.00 |
| *Sorghum halepense* | Johnsongrass | 2.00 |
| *Cucurbita foetidissima* | Missouri gourd | 1.75 |
| *Phytolacca americana* | American pokeweed | 1.28 |
| *Torilis arvensis* | spreading hedgeparsley | 1.26 |
| *Acalypha ostryifolia* | pineland threeseed mercury | 1.25 |
| *Lactuca serriola* | prickly lettuce | 1.25 |
| *Cirsium altissimum* | tall thistle | 0.75 |
| *Helianthus annuus* | common sunflower | 0.51 |
| *Gleditsia triacanthos* | honeylocust | 0.50 |
| *Physalis longifolia* | longleaf groundcherry | 0.03 |

# Discussion

Tallgrass Prairie National Preserve combines a unique mix of historically important structures and a significant example of native tallgrass prairie.

## Field Survey

The vegetation data presented in this project should be used as a baseline to build upon. New survey work in a timely manner would greatly improve both the classification and mapping efforts. Also, accessing neighboring private lands would allow new plot samples to be obtained, increasing the confidence in these types, thereby strengthening the classification.

## NVC Classification

In addition to providing a highly accurate vegetation map of the park and environs, we were able to particularly focus on mapping rocky mixed prairie, a sub-community of native tallgrass prairie that is present on limestone outcrops throughout the park.

## Digital Imagery and Interpretation

Multiple sources of imagery were used to digitize the vegetation map, which allowed very thorough examination of subtle vegetation characteristics and photo signatures (e.g., shadows of canopy trees). Analyzing imagery taken over multiple seasons, multiple years, and with multiple color band displays allowed us to map boundaries in fine detail and with high confidence.

## Accuracy Assessment

We were able to obtain a 92.0% accuracy for map classes, and a kappa adjustment for chance agreements results in an overall accuracy of 90.6%. Our overall accuracy assessment is well above the 80% required by VMP (taking into account the 90% confidence interval). Individual accuracies also met the 80% requirement, with two exceptions:

(1) Cropland: Users' accuracy for this vegetation class is 67%, with a 90% confidence interval of 5%-128%. Of the three accuracy assessment sites mapped as cropland, one was determined to be smooth brome on the ground. Producers' accuracy is 100%, with a 90% confidence interval of 75%-125%.

(2) Central Green Ash - Elm - Hackberry Forest: Producers' accuracy for this vegetation class is 75%, with a 90% confidence interval of 44%-106%. Of the eight accuracy assessment sites classified as this category on the ground, one was mapped as wet ravine and one was mapped as bur oak forest. These three categories were sometimes difficult to distinguish from overhead imagery. Users' accuracy is 86%, with a 90% confidence interval of 57%-115%.

## 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 TAPR and the most accurate and detailed GIS layer, this project should be viewed as a place to start rather than an end product. Present and future NPS staff are 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 TAPR 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 with respect to the agricultural aspect warrants periodic **field surveys** by experienced ecologists. The inaccessibility of private lands in the environs should be addressed by seeking permission to sample and verify 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. GPS receiver 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 be updated with more current and accurate information.

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

4. 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. These 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 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 to 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: contingency Table for Vegetation Mapping at TAPR

| | Map Units | Tallgrass Prairie | Rocky Mixed Prairie | Wet Ravine | Success. Forest | Weedy | Bur Oak | Smooth Brome | Cropland | Restored Priairie | Totals | Commission Accuracy | 90% Conf. Interval | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | - | + |
| **Sample Data (Polygon Map Data)** | Tallgrass Prairie | **19** | 1 | | | 1 | | | | | 21 | 90% | 78% | 103% |
| | Rocky Mixed Prairie | 1 | **25** | | | | | | | | 26 | 96% | 88% | 104% |
| | Wet Ravine | | | **14** | 1 | | 1 | | | | 16 | 88% | 71% | 104% |
| | Success. Forest | | | | **6** | | 1 | | | | 7 | 86% | 57% | 115% |
| | Weedy | | | | | **8** | | 1 | | | 9 | 89% | 66% | 112% |
| | Bur Oak | | | | 1 | | **12** | | | | 13 | 92% | 76% | 108% |
| | Smooth Brome | | | | | | | **12** | | | 12 | 100% | 96% | 104% |
| | Cropland | | | | | | | 1 | **2** | | 3 | 67% | 5% | 128% |
| | Restored Prairie | | | | | | | | | **5** | 5 | 100% | 90% | 110% |
| | Totals | 20 | 26 | 14 | 8 | 9 | 14 | 14 | 2 | 5 | | | | |
| **Producer's Error** | Omission Accuracy | 95% | 96% | 100% | 75% | 89% | 86% | 86% | 100% | 100% | **103 Total Correct Points** | | | |
| | 90% Conf. - | 84% | 88% | 96% | 44% | 66% | 67% | 67% | 75% | 90% | **112 Total Points** | | | |
| | Level + | 106% | 104% | 104% | 106% | 112% | 105% | 105% | 125% | 110% | | | | |
| **Overall Total Accuracy = 92.0%  Overall Kappa Index = 90.6%  Overall 90% Upper and Lower Confidence Interval =87.3% and 96.6%** | | | | | | | | | | | | | | |

Instructions on Using the Accuracy Assessment Contingency Table:

The contingency table or error matrix found above 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.

# Appendix B: Example of a Plot Sampling Form

IDENTIFIERS/LOCATORS

Plot Code_____

Provisional Community Name_____

State ___ Site Name_____ Local Site Name_____

Quad Name_____

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

Datum_____ 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_____

Project Name_____ Project Leader_____

Survey Date_____ Surveyor Lead _____Surveyors_____

Taxonomic authority _____

Directions to Plot

Plot length_____ Plot width_____ Plot area _____

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

Plot representativeness

ENVIRONMENTAL DESCRIPTION

Elevation _____ Slope _____ Aspect_____

Topographic Position

| Cowardan System | Non-Tidal | | Tidal |
|---|---|---|---|
| ___Upland ___Riverine<br>___Palustrine ___Lacustrine | ___Permanently Flooded<br>___Semipermanently Flooded<br>___Seasonally Flooded<br>___Temporarily Flooded | ___Saturated<br>___Seasonally Flooded/Saturated<br>___Intermittently Flooded | ___ _____ |

| Environmental Comments: | Soil Drainage<br>___ Rapidly drained ___ Well drained<br>___ Moderately well drained ___ Somewhat poorly drained<br>___ Poorly drained ___ Very poorly drained |
|---|---|
| Soil Comments | Landscape/Landform Comments |

1

VEGETATION DESCRIPTION

| Leaf phenology (of dominant stratum) | Leaf Type (of dominant stratum) | Physiognomic class | Cover Scale for Species | Height Scale for Strata |
|---|---|---|---|---|
| Trees or Shrubs<br>___Evergreen<br>___Cold-deciduous<br>___Drought-deciduous<br>___Mixed evergreen - cold-deciduous<br>___Mixed evergreen - drought-deciduous<br><br>Herbs<br>___Annual<br>___Perennial | ___Broad-leaved<br>___Needle-leaved<br>___Microphyllous<br>___Graminoid<br>___Forb<br>___Pteridophyte | ___Forest<br>___Woodland<br>___Shrubland<br>___Dwarf-shrubland<br>___Herbaceous<br>___Nonvascular<br>___Sparsely Vegetated | √ Nearby<br>1 0-.01%<br>2 .01-1%<br>3 1-2%<br>4 2-5%<br>5 5-10%<br>6 10-25%<br>7 25-50%<br>8 50-75%<br>9 75-95%<br>10 95-100% | 01 <0.5 m<br>02 0.5-1m<br>03 1-2 m<br>04 2-5 m<br>05 5-10 m<br>06 10-15 m<br>07 15-20 m<br>08 20-35 m<br>09 35 - 50 m<br>10 >50 m |

| Layer (sublayer–optional) | Height Class | Layer % Cover | Dominant and characteristic Species and Cover Class |
|---|---|---|---|
| **T Tree** | | | |
| T_ | | | |
| T_ | | | |
| **S Shrub** | | | |
| S_ | | | |
| S_ | | | |
| **H Herbaceous** | | | |
| **N Nonvascular** | | | |
| _ | | | |

*please see above table for height and cover scales*

Animal Use Evidence

Natural and Anthropogenic Disturbance Comments

Other Comments

2

# Appendix C: Tallgrass Prairie National Preserve Dichotomous Key to Vegetation Associations

1a. Plant community dominated by trees…….....……**2**

1b. Plant community dominated by herbaceous vegetation. If woody plants are present, they are scattered individuals or brush due to lack of recent fire.....**3**

2a. Woodland or forest of mixed trees of mixed heights, and mixed ages with no old growth trees.....
**Central Green Ash – Elm – Hackberry Forest CEGL00214**

2b. Forest with mix of trees, but includes old-growth bur oaks.....
**Western Tallgrass Bur Oak Woodland CEGL002053**

3a. Dominated by planted non-native plants.....**4**

3b. Dominated by native grasses and native forbs.....**6**

4a. Dominated by non-native grasses and annual forbs (annual forbs >5% cover).....**Weedy**

4b. Dominated by non-native grasses or crop; if forbs are present, <5% cover.....**5**

5a. Planted brome grass.....**Smooth Brome grass *Bromus inermis* Semi-natural Herbaceous Alliance**

5b. Planted agricultural crops.....**Cropland**

6a. Native prairie with forbs.....**7**

6b. Replanted or Restored Tallgrass Prairie.....**Planted Semi-natural Restored Tallgrass Prairie**

7a. Dominated by plants associated with wet places (*Eleocharis, Spartina, Amorpha fruticosa)*.....**8**

7b. Dominated by *Andropogon gerardii*.....**9**

8a. At a spring or seep.....**Spring or Seep**

8b. In a riparian area near a stream.....**Southern Great Plains Cordgrass Wet Prairie CEGL002223**

9a. Greater than 5% rock cover.....**Central Great Plains Little Bluestem Prairie CEGL002246**

9b. Less than 5% rock cover.....**Flint Hills Tallgrass Prairie CEGL002201**

# Appendix D: Example of an Accuracy Assessment Sampling Form

**NPS Vegetation Mapping: Accuracy Assessment Form**

Plot #_____ Park Code: **TAPR** Observers: _____ Date: _____
UTM X __ __ __ __ __ __m E UTM Y __ __ __ __ __ __ __ m N Zone: _____
Datum: _____ PDOP_____ Elevation _____ Waypoint: _____
Topography: _____ Slope: _____ Picture no(s): _____

| | Stratum | Height (m) | % Cover of Strata | Major Species Present | % Cover of Each Species |
|---|---|---|---|---|---|
| T1 | Emergent | | | | |
| T2 | Canopy | | | | |
| T3 | Subcanopy (<10 cm DBH) | | | | |
| S1 | Tall Shrub (2-5 m) | | | | |
| S2 | Short Shrub (<2m) | | | | |
| H | Herbaceous | | | | |
| A1 | Floating Leaved Aquatic | | | | |
| A2 | Submerged Aquatic | | | | |
| N | Nonvascular | | | | |

Comments on indicator species or rare species: _____
_____

Mapped Vegetation Association: _____

Observed Vegetation Association: _____

Comments (note influences on vegetation, difficulties with classification, etc):

# Appendix E: Tallgrass Prairie National Preserve Species List

| Family | Scientific Name | Common Name |
|---|---|---|
| **Acanthaceae** | *Justicia americana* | American water-willow |
| | *Ruellia humilis* | fringeleaf wild petunia |
| **Aceraceae** | *Acer negundo* | boxelder |
| **Amaranthaceae** | *Amaranthus palmeri* | carelessweed |
| | *Amaranthus tuberculatus* | roughfruit amaranth |
| **Anacardiaceae** | *Rhus aromatica* | fragrant sumac |
| | *Rhus glabra* | smooth sumac |
| | *Toxicodendron radicans* | eastern poison ivy |
| **Apiaceae** | *Cicuta maculata* | spotted water hemlock |
| | *Lomatium foeniculaceum* | desert biscuitroot |
| | *Spermolepis inermis* | Red River scaleseed |
| | *Torilis arvensis* | spreading hedgeparsley |
| **Apocynaceae** | *Apocynum cannabinum* | Indianhemp |
| **Asclepiadaceae** | *Asclepias sullivantii* | prairie milkweed |
| | *Asclepias syriaca* | common milkweed |
| | *Asclepias tuberosa* | butterfly milkweed |
| | *Asclepias verticillata* | whorled milkweed |
| | *Asclepias viridiflora* | green comet milkweed |
| | *Asclepias viridis* | green antelopehorn |
| **Asteraceae** | *Achillea millefolium* | common yarrow |
| | *Ageratina altissima* | white snakeroot |
| | *Ambrosia artemisiifolia* | annual ragweed |
| | *Ambrosia psilostachya* | Cuman ragweed |
| | *Ambrosia trifida* | great ragweed |
| | *Amphiachyris dracunculoides* | prairie broomweed |
| | *Antennaria neglecta* | field pussytoes |
| | *Arnoglossum plantagineum* | groovestem Indian plaintain |
| | *Artemisia ludoviciana* | white sagebrush |
| | *Bidens frondosa* | devil's beggartick |
| | *Brickellia eupatorioides* | false boneset |
| | *Cirsium altissimum* | tall thistle |
| | *Cirsium undulatum* | wavyleaf thistle |
| | *Conyza canadensis* | Canadian horseweed |
| | *Echinacea angustifolia* | blacksamson echinacea |
| | *Eclipta prostrata* | false daisy |
| | *Erechtites hieraciifolia* | American burnweed |
| | *Erigeron annuus* | eastern daisy fleabane |
| | *Erigeron philadelphicus* | Philadelphia fleabane |
| | *Erigeron strigosus* | prairie fleabane |
| | *Eupatorium altissimum* | tall thoroughwort |
| | *Euthamia gymnospermoides* | Texas goldentop |
| | *Helianthus annuus* | common sunflower |
| | *Helianthus grosseserratus* | sawtooth sunflower |
| | *Helianthus maximiliani* | Maximilian sunflower |
| | *Helianthus pauciflorus* | stiff sunflower |

| Family | Scientific Name | Common Name |
|---|---|---|
| | *Hieracium longipilum* | hairy hawkweed |
| | *Hymenopappus scabiosaeus* | Carolina woollywhite |
| | *Iva annua* | annual marshelder |
| | *Krigia caespitosa* | weedy dwarfdandelion |
| | *Lactuca canadensis* | Canada lettuce |
| | *Lactuca saligna* | willowleaf lettuce |
| | *Lactuca serriola* | prickly lettuce |
| | *Liatris punctata* | dotted blazing star |
| | *Nothocalais cuspidata* | prairie false dandelion |
| | *Oligoneuron rigidum* | stiff goldenrod |
| | *Packera plattensis* | prairie groundsel |
| | *Ratibida columnifera* | upright prairie coneflower |
| | *Ratibida pinnata* | pinnate prairie coneflower |
| | *Rudbeckia hirta* | blackeyed Susan |
| | *Silphium integrifolium* | wholeleaf rosinweed |
| | *Silphium laciniatum* | compassplant |
| | *Solidago canadensis* | Canada goldenrod |
| | *Solidago gigantea* | giant goldenrod |
| | *Solidago missouriensis* | Missouri goldenrod |
| | *Solidago speciosa* | showy goldenrod |
| | *Symphyotrichum ericoides* | white heath aster |
| | *Symphyotrichum laeve* | smooth blue aster |
| | *Symphyotrichum lanceolatum* | white panicle aster |
| | *Symphyotrichum oblongifolium* | aromatic aster |
| | *Symphyotrichum praealtum* | willowleaf aster |
| | *Symphyotrichum sericeum* | western silver aster |
| | *Taraxacum officinale* | common dandelion |
| | *Verbesina alternifolia* | wingstem |
| | *Vernonia baldwinii* | Baldwin's ironweed |
| | *Xanthium strumarium* | rough cockleburr |
| **Boraginaceae** | *Lithospermum canescens* | hoary puccoon |
| | *Lithospermum incisum* | narrowleaf stoneseed |
| | *Myosotis verna* | spring forget-me-not |
| | *Onosmodium bejariense* | soft-hair marbleseed |
| **Brassicaceae** | *Alliaria petiolata* | garlic mustard |
| | *Camelina microcarpa* | littlepod false flax |
| | *Descurainia pinnata* | western tansymustard |
| | *Draba brachycarpa* | shortpod draba |
| | *Draba cuneifolia* | wedgeleaf draba |
| | *Draba reptans* | Carolina draba |
| | *Lepidium densiflorum* | common pepperweed |
| | *Nasturtium officinale* | watercress |
| | *Thlaspi arvense* | field pennycress |
| **Cactaceae** | *Escobaria missouriensis* | Missouri foxtail cactus |
| | *Opuntia macrorhiza* | twistspine pricklypear |
| **Campanulaceae** | *Lobelia siphilitica* | great blue lobelia |
| | *Triodanis perfoliata* | clasping Venus' looking-glass |

| Family | Scientific Name | Common Name |
|---|---|---|
| **Caprifoliaceae** | *Sambucus nigra* | European black elderberry |
| | *Symphoricarpos orbiculatus* | coralberry |
| **Caryophyllaceae** | *Cerastium brachypodum* | shortstalk chickweed |
| | *Dianthus armeria* | Deptford pink |
| | *Silene antirrhina* | sleepy silene |
| | *Stellaria media* | common chickweed |
| **Chenopodiaceae** | *Bassia scoparia* | burningbush |
| | *Chenopodium album* | lambsquarters |
| **Commelinaceae** | *Tradescantia bracteata* | longbract spiderwort |
| **Convolvulaceae** | *Calystegia sepium* | hedge false bindweed |
| | *Convolvulus arvensis* | field bindweed |
| | *Evolvulus nuttallianus* | shaggy dwarf morning-glory |
| **Cornaceae** | *Cornus drummondii* | roughleaf dogwood |
| **Cucurbitaceae** | *Cucurbita foetidissima* | Missouri gourd |
| **Cupressaceae** | *Juniperus virginiana* | eastern redcedar |
| **Cyperaceae** | *Carex annectens* | yellowfruit sedge |
| | *Carex austrina* | southern sedge |
| | *Carex bicknellii* | Bicknell's sedge |
| | *Carex brevior* | shortbeak sedge |
| | *Carex frankii* | Frank's sedge |
| | *Carex gravida* | heavy sedge |
| | *Carex molesta* | troublesome sedge |
| | *Carex muehlenbergii* | Muhlenberg's sedge |
| | *Carex vulpinoidea* | fox sedge |
| | *Cyperus acuminatus* | tapertip flatsedge |
| | *Cyperus esculentus* | yellow nutsedge |
| | *Cyperus lupulinus* | Great Plains flatsedge |
| | *Cyperus odoratus* | fragrant flatsedge |
| | *Cyperus setigerus* | lean flatsedge |
| | *Cyperus strigosus* | strawcolored flatsedge |
| | *Eleocharis compressa* | flatstem spikerush |
| | *Schoenoplectus tabernaemontani* | softstem bulrush |
| | *Scirpus atrovirens* | green bulrush |
| | *Scirpus pendulus* | rufous bulrush |
| **Euphorbiaceae** | *Acalypha ostryifolia* | pineland threeseed mercury |
| | *Acalypha rhomboidea* | common threeseed mercury |
| | *Acalypha virginica* | Virginia threeseed mercury |
| | *Chamaesyce maculata* | spotted sandmat |
| | *Chamaesyce nutans* | eyebane |
| | *Chamaesyce prostrata* | prostrate sandmat |
| | *Croton capitatus* | hogwort |
| | *Croton monanthogynus* | prairie tea |
| | *Euphorbia dentata* | toothed spurge |
| | *Euphorbia marginata* | snow on the mountain |
| | *Euphorbia spathulata* | warty spurge |
| | *Tragia betonicifolia* | betonyleaf noseburn |
| **Fabaceae** | *Amorpha canescens* | leadplant |

| Family | Scientific Name | Common Name |
|---|---|---|
| | *Amorpha fruticosa* | desert false indigo |
| | *Astragalus canadensis* | Canadian milkvetch |
| | *Astragalus crassicarpus* | groundplum milkvetch |
| **Fabaceae** | *Baptisia alba* | white wild indigo |
| | *Baptisia australis* | blue wild indigo |
| | *Baptisia bracteata* | longbract wild indigo |
| | *Cercis canadensis* | eastern redbud |
| | *Chamaecrista fasciculata* | partridge pea |
| | *Dalea candida* | white prairie clover |
| | *Dalea multiflora* | roundhead prairie clover |
| | *Dalea purpurea* | violet prairie clover |
| | *Desmanthus illinoensis* | prairie bundleflower |
| | *Desmodium glutinosum* | pointedleaf ticktrefoil |
| | *Desmodium illinoense* | Illinois ticktrefoil |
| | *Desmodium sessilifolium* | sessileleaf ticktrefoil |
| | *Gleditsia triacanthos* | honeylocust |
| | *Glycine max* | soybean |
| | *Glycyrrhiza lepidota* | American licorice |
| | *Gymnocladus dioicus* | Kentucky coffeetree |
| | *Lespedeza capitata* | roundhead lespedeza |
| | *Lespedeza violacea* | violet lespedeza |
| | *Lotus unifoliolatus* | American bird's-foot trefoil |
| | *Medicago lupulina* | black medick |
| | *Melilotus officinalis* | yellow sweetclover |
| | *Mimosa nuttallii* | Nuttall's sensitive-briar |
| | *Pediomelum argophyllum* | silverleaf Indian breadroot |
| | *Psoralidium tenuiflorum* | slimflower scurfpea |
| | *Robinia pseudoacacia* | black locust |
| | *Strophostyles leiosperma* | slickseed fuzzybean |
| **Fagaceae** | *Quercus macrocarpa* | bur oak |
| | *Quercus muehlenbergii* | chinkapin oak |
| **Fumariaceae** | *Corydalis micrantha* | smallflower fumewort |
| **Gentianaceae** | *Gentiana puberulenta* | downy gentian |
| **Geraniaceae** | *Geranium carolinianum* | Carolina geranium |
| **Hippocastanaceae** | *Aesculus glabra* | Ohio buckeye |
| **Iridaceae** | *Sisyrinchium campestre* | prairie blue-eyed grass |
| **Juglandaceae** | *Carya texana* | black hickory |
| | *Juglans nigra* | black walnut |
| **Juncaceae** | *Juncus dudleyi* | Dudley's rush |
| | *Juncus interior* | inland rush |
| | *Juncus torreyi* | Torrey's rush |
| **Lamiaceae** | *Hedeoma hispida* | rough false pennyroyal |
| | *Lamium amplexicaule* | henbit deadnettle |
| | *Lycopus americanus* | American water horehound |
| | *Monarda fistulosa* | wild bergamot |
| | *Prunella vulgaris* | common selfheal |
| | *Salvia azurea* | azure blue sage |

| Family | Scientific Name | Common Name |
|---|---|---|
| | *Scutellaria parvula* | small skullcap |
| | *Teucrium canadense* | Canada germander |
| | *Trichostema brachiatum* | fluxweed |
| **Lemnaceae** | *Lemna minor* | common duckweed |
| **Liliaceae** | *Allium spp.* | onion |
| | *Erythronium mesochoreum* | midland fawnlily |
| | *Nothoscordum bivalve* | crowpoison |
| | *Zigadenus nuttallii* | Nuttall's deathcamas |
| **Linaceae** | *Linum sulcatum* | grooved flax |
| **Loasaceae** | *Mentzelia oligosperma* | chickenthief |
| **Lythraceae** | *Ammannia coccinea* | valley redstem |
| | *Lythrum alatum* | winged lythrum |
| **Malvaceae** | *Abutilon theophrasti* | velvetleaf |
| | *Callirhoe alcaeoides* | light poppymallow |
| | *Sida spinosa* | prickly fanpetals |
| **Menispermaceae** | *Menispermum canadense* | moonseed |
| **Molluginaceae** | *Mollugo verticillata* | green carpetweed |
| **Moraceae** | *Maclura pomifera* | osage orange |
| | *Morus alba* | white mulberry |
| | *Morus rubra* | red mulberry |
| **Nyctaginaceae** | *Mirabilis albida* | white four o'clock |
| | *Mirabilis nyctaginea* | heartleaf four o'clock |
| **Oleaceae** | *Fraxinus americana* | white ash |
| | *Fraxinus pennsylvanica* | green ash |
| **Onagraceae** | *Gaura mollis* | velvetweed |
| | *Ludwigia alternifolia* | seedbox |
| | *Ludwigia peploides* | floating primrose-willow |
| | *Oenothera biennis* | common evening-primrose |
| | *Oenothera laciniata* | cutleaf evening primrose |
| | *Oenothera macrocarpa* | bigfruit evening-primrose |
| | *Oenothera speciosa* | pinkladies |
| **Orchidaceae** | *Spiranthes cernua* | nodding lady's tresses |
| **Oxalidaceae** | *Oxalis stricta* | common yellow oxalis |
| | *Oxalis violacea* | violet woodsorrel |
| **Phytolaccaceae** | *Phytolacca americana* | American pokeweed |
| **Plantaginaceae** | *Plantago rhodosperma* | redseed plantain |
| | *Plantago rugelii* | blackseed plantain |
| | *Plantago virginica* | Virginia plantain |
| **Platanaceae** | *Platanus occidentalis* | American sycamore |
| **Poaceae** | *Alopecurus carolinianus* | Carolina foxtail |
| | *Andropogon gerardii* | big bluestem |
| | *Aristida oligantha* | prairie threeawn |
| | *Bothriochloa laguroides* | silver beardgrass |
| | *Bouteloua curtipendula* | sideoats grama |
| | *Bouteloua dactyloides* | buffalograss |
| | *Bouteloua gracilis* | blue grama |
| | *Bouteloua hirsuta* | hairy grama |

| Family | Scientific Name | Common Name |
|---|---|---|
| | *Bromus arvensis* | field brome |
| | *Bromus inermis* | smooth brome |
| | *Chloris verticillata* | tumble windmill grass |
| | *Dichanthelium acuminatum* | tapered rosette grass |
| | *Dichanthelium oligosanthes* | Heller's rosette grass |
| | *Dichanthelium wilcoxianum* | fall rosette grass |
| | *Digitaria cognata* | fall witchgrass |
| **Poaceae** | *Digitaria sanguinalis* | hairy crabgrass |
| | *Echinochloa muricata* | rough barnyardgrass |
| | *Elymus canadensis* | Canada wildrye |
| | *Elymus virginicus* | Virginia wildrye |
| | *Eragrostis spectabilis* | purple lovegrass |
| | *Festuca subverticillata* | nodding fescue |
| | *Glyceria striata* | fowl mannagrass |
| | *Koeleria macrantha* | prairie Junegrass |
| | *Leersia oryzoides* | rice cutgrass |
| | *Leptochloa panicea* | mucronate sprangletop |
| | *Muhlenbergia cuspidata* | plains muhly |
| | *Muhlenbergia mexicana* | Mexican muhly |
| | *Panicum capillare* | witchgrass |
| | *Panicum virgatum* | switchgrass |
| | *Paspalum pubiflorum* | hairyseed paspalum |
| | *Poa pratensis* | Kentucky bluegrass |
| | *Schedonorus phoenix* | tall fescue |
| | *Schizachyrium scoparium* | little bluestem |
| | *Setaria faberi* | Japanese bristlegrass |
| | *Setaria pumila* | yellow bristlegrass |
| | *Setaria viridis* | green bristlegrass |
| | *Sorghastrum nutans* | Indiangrass |
| | *Sorghum halepense* | Johnsongrass |
| | *Spartina pectinata* | prairie cordgrass |
| | *Sphenopholis obtusata* | prairie wedgescale |
| | *Sporobolus compositus* | composite dropseed |
| | *Sporobolus heterolepis* | prairie dropseed |
| | *Sporobolus neglectus* | puffsheath dropseed |
| | *Sporobolus vaginiflorus* | poverty dropseed |
| | *Tridens flavus* | purpletop tridens |
| | *Tripsacum dactyloides* | eastern gamagrass |
| | *Vulpia octoflora* | sixweeks fescue |
| **Polygalaceae** | *Polygala verticillata* | whorled milkwort |
| **Polygonaceae** | *Polygonum amphibium* | water knotweed |
| | *Polygonum persicaria* | spotted ladysthumb |
| | *Rumex altissimus* | pale dock |
| | *Rumex crispus* | curly dock |
| **Portulacaceae** | *Portulaca oleracea* | little hogweed |
| **Primulaceae** | *Androsace occidentalis* | western rockjasmine |
| **Pteridaceae** | *Pellaea glabella* | smooth cliffbrake |

| Family | Scientific Name | Common Name |
|---|---|---|
| **Ranunculaceae** | *Delphinium carolinianum* | Carolina larkspur |
| | *Myosurus minimus* | tiny mousetail |
| **Rhamnaceae** | *Ceanothus americanus* | New Jersey tea |
| | *Ceanothus herbaceus* | Jersey tea |
| **Rosaceae** | *Agrimonia parviflora* | harvestlice |
| | *Geum canadense* | white avens |
| | *Prunus americana* | American plum |
| | *Rosa arkansana* | prairie rose |
| **Rubiaceae** | *Galium aparine* | stickywilly |
| **Salicaceae** | *Populus deltoides* | eastern cottonwood |
| | *Salix interior* | sandbar willow |
| | *Salix nigra* | black willow |
| **Santalaceae** | *Comandra umbellata* | bastard toadflax |
| **Scrophulariaceae** | *Leucospora multifida* | narrowleaf paleseed |
| | *Mimulus ringens* | Allegheny monkeyflower |
| | *Veronica anagallis-aquatica* | water speedwell |
| | *Veronica arvensis* | corn speedwell |
| | *Veronica peregrina* | neckweed |
| **Solanaceae** | *Physalis heterophylla* | clammy groundcherry |
| | *Physalis longifolia* | longleaf groundcherry |
| | *Physalis pumila* | dwarf groundcherry |
| | *Physalis virginiana* | Virginia groundcherry |
| | *Solanum carolinense* | Carolina horsenettle |
| | *Solanum rostratum* | buffalobur nightshade |
| **Tiliaceae** | *Tilia americana* | American basswood |
| **Ulmaceae** | *Celtis occidentalis* | common hackberry |
| | *Ulmus americana* | American elm |
| | *Ulmus rubra* | slippery elm |
| **Urticaceae** | *Boehmeria cylindrica* | smallspike false nettle |
| | *Laportea canadensis* | Canadian woodnettle |
| | *Parietaria pensylvanica* | Pennsylvania pellitory |
| | *Urtica dioica* | stinging nettle |
| **Verbenaceae** | *Glandularia bipinnatifida* | Dakota mock vervain |
| | *Verbena hastata* | swamp verbena |
| | *Verbena simplex* | narrowleaf vervain |
| | *Verbena stricta* | hoary verbena |
| | *Verbena urticifolia* | white vervain |
| **Violaceae** | *Hybanthus verticillatus* | babyslippers |
| | *Viola bicolor* | field pansy |
| | *Viola nephrophylla* | northern bog violet |
| | *Viola pedatifida* | prairie violet |
| **Vitaceae** | *Parthenocissus quinquefolia* | Virginia creeper |

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 031/107299, April 2011

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

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