National Park Service
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Natural Resource Stewardship and Science

Vegetation Classification and Mapping of Pipestone National Monument, Minnesota

Project Report

Natural Resource Report NPS/PIPE/NRR—2014/802

ON THE COVER
Lake Hiawatha
Photograph by: Nathan King, Pipestone National Monument

NPS Vegetation Inventory Program
Pipestone National Monument

Vegetation Classification and Mapping of Pipestone National Monument, Minnesota

Project Report

Natural Resource Report NPS/PIPE/NRR—2014/802

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

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

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

*contact diamondd@missouri.edu

April 2014

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

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Please cite this publication as:

Diamond, D. D., L. F. Elliott, M. D. DeBacker, K. M. James, D. L. Pursell, and A. Struckhoff. 2014. Vegetation mapping and classification of Pipestone National Monument, Minnesota: Project report. Natural Resource Report NPS/PIPE/NRR—2014/802. National Park Service, Fort Collins, Colorado.

NPS 372/124454, April 2014

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Abstract/Executive Summary

Pipestone National Monument (PIPE) is situated in southwestern Minnesota, just north of the town of Pipestone. The site was established in 1937 to protect quarries of pipestone (catlinite) used by Native Americans from prehistoric times, and continuing into the present.

A vegetation classification and mapping project was initiated in 2011 and completed in 2013. Protocols and products were produced following National Park Service Vegetation Inventory Program guidelines. Classification was based on 35 field plots and 46 georeferenced observation points. Mapping was based on air photo interpretation and heads-up digitizing of polygons. Accuracy assessment points obtained during 2013 verified that the map is 97.9% accurate.

Ten vegetation types were classified and mapped. Central Mesic Tallgrass Prairie accounted for 57.3% of the non-developed, vegetated area of the monument (157.1 acres, 63.6 hectares). This type supported a good compliment of native grasses and forbs, but non-natives were also components of the community. The type occupied well-drained uplands to moderately drained, deep-soiled, low flats. Restored Tallgrass Prairie on former croplands was continuous with unbroken sod on the western side of the monument, and made up 24.4% of the area (67.0 acres, 27.1 hectares). A Sioux quartzite outcrop bisects the monument from north to south on the east side, and in some areas forms a bluff. A shallow-soiled Northern Tallgrass Quartzite Outcrop community occupied a narrow zone near the lip of the bluff and extending along the length of the outcrop from north to south (5.4% of the monument). Bur Oak Woodland occurred in a narrow zone below the bluff in areas where it was formed by the quartzite outcrop (1.9% of the monument). False indigo bush shrubland and floodplain forest communities were associated with Pipestone Creek, which meanders roughly east to west across the central part of the monument. Other ruderal grassland and a shrubland types occurred in small patches across the park in response to human disturbance, but together made up less than 5% of the area.

Introduction

Pipestone National Monument Vegetation Inventory Project

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

The project was initiated because accurate maps of existing vegetation facilitate natural and cultural resource management and interpretation. PIPE supports native tallgrass prairie remnants over both deep and shallow, quartzite-influenced soils, and thus offers opportunities for prairie conservation. It also supports a population of the rare western prairie fringed orchid (*Platanthera praeclara*), which is now monitored on an on-going basis (Young and Haack 2009). Each NPS Vegetation Inventory Project has three major components: classification, mapping, and map accuracy assessment. This report provides details on each of these fundamental elements.

NPS Vegetation Inventory Program

The National Vegetation Inventory Program (VIP) was established to map, classify, and describe vegetation in National Park units. It is administered by the NPS Biological Resources Management Division and provides baseline vegetation information to the NPS Natural Resource Inventory and Monitoring Program (I&M).

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

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

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

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

Vegetation Mapping Program Standards

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

Protocols

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

Standards

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

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

Pipestone National Monument

Pipestone National Monument is located north of the town of Pipestone, in southwest Minnesota (Figure 1) and consists of the 294.7 acres (119.3 ha). The site was established in 1937 to protect quarries of pipestone (catlinite) used by Native Americans from prehistoric times, and continuing into the present. According to the U.S. Environmental Protection Agency, a Level III ecoregion line bisects the site from east to west, near the center of the monument. To the north lies the Big Sioux Basin Level IV ecoregion within the Northern Glaciated Plains Level III ecoregion, and to the south lies the Loess Prairies Level IV ecoregion within the Western Cornbelt Plains Level III ecoregion. The chief difference in these ecoregions is the presence of lakes to the south and not

to the north, and more recent glaciation to the north. Both ecoregions were dominated by tallgrass prairie in pre-European times.

PIPE supports some areas of unbroken native sod over deep soils, a tallgrass prairie restoration, and an outcrop of Sioux quartzite with thin soils (James 2011). A population of rare western prairie fringed orchid is present on the park and has been monitored by Heartland Network biologists (see Young and Haack 2009). Linear, hand-excavated quarries are present, and some are still active.

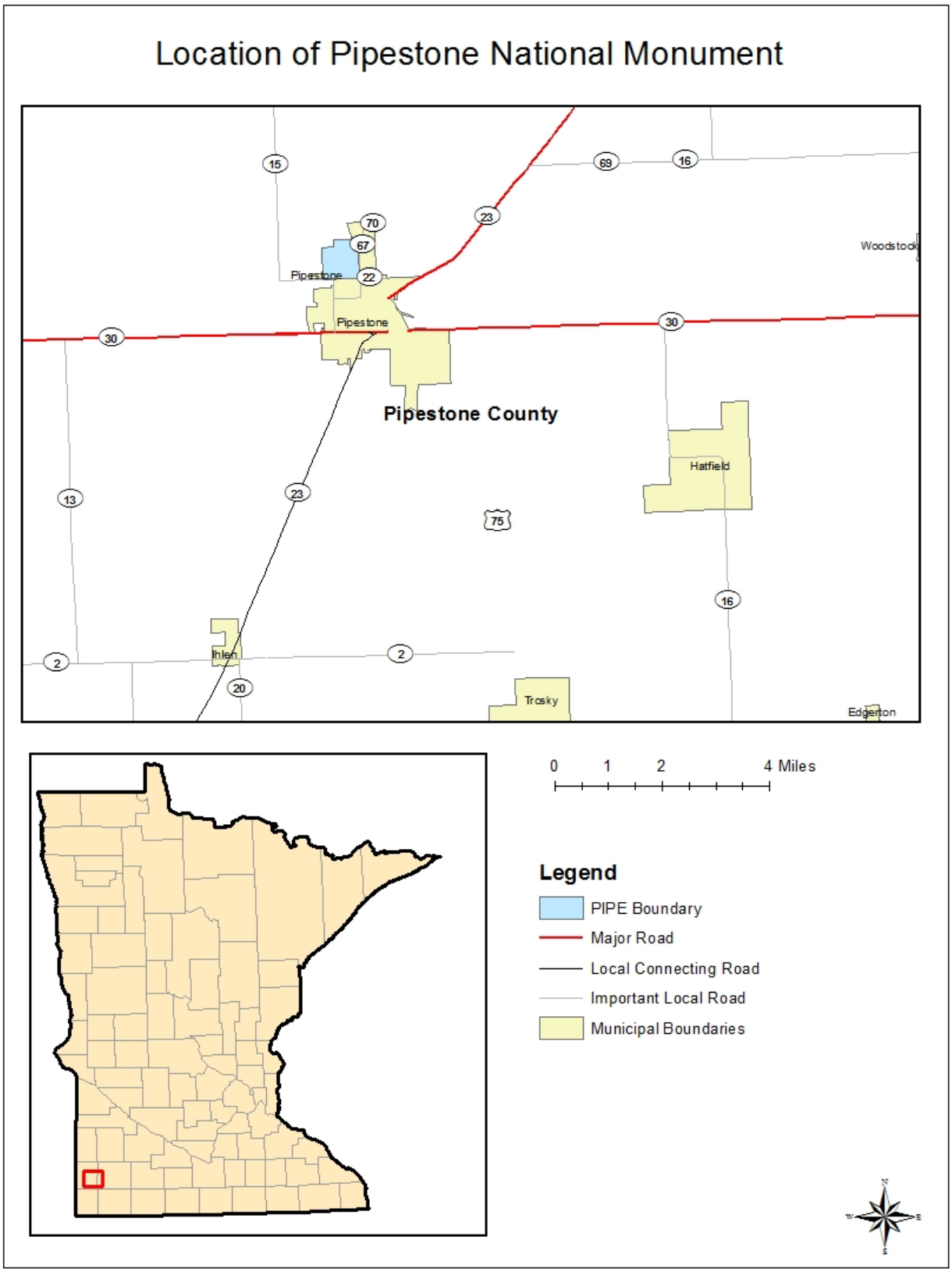


Figure 1. Location of Pipestone National Monument.

Project Statistics

Field Work 2011 - 2013:

Plot Sampling = 35
Plots sampled in June 2012 by MoRAP staff

Accuracy Assessment Points = 53
All collected in June 2013 by Heartland Inventory and Monitoring Network staff

Observation Points = 46
Collected mainly in September 2011 and June 2012 by MoRAP staff

Classification:

5 NVC Plant Associations
5 Park Special Vegetation Classes
2 Non-Vegetated Land-Use Class (not including water)

GIS Database 2011 - 2013:

Pipestone National Monument = 294.7 acres (119.3 hectares)

Base Imagery used for mapping (acquired by MoRAP):
2010, Pipestone County, MN, leaf-on, true color, 1m
2006, Pipestone County, MN, leaf-on, CIR

Additional Imagery acquired and viewed by MoRAP:
2008, Pipestone County, MN, leaf-on, true color, 1 m
2009, Pipestone County, MN, leaf-on, true color, 1 m
Bing Aerial Imagery
1968, Pipestone County, MN, black and white
1938, Pipestone County, MN, black and white

Minimum Mapping Unit = 0.5 hectare
Minimum Patch Size=.007 hectares
Total Size = 55 Polygons
Average Polygon Size = 5.39 acres (2.18 hectares)
Overall Thematic Accuracy = 97.9%
Project Completion Date: 12/2013

Methods

Pipestone National Monument, at 294.7 acres, is a small park as defined by sampling design protocols (TNC and ESRI 1994), so most of the mapped vegetation polygons were visited for this study. Since access to private lands outside of the park was not ensured, the project boundary consisted of the boundary of the park itself (Figure 2). Five major tasks were identified and completed, including:

1. Plan, gather data, and coordinate tasks;

2. Survey PIPE to understand and sample the vegetation;

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

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

5. Assess the accuracy of the final map product.

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

Planning, Data Gathering, and Coordination

The vegetation mapping project was discussed with appropriate park staff in coordination with Heartland Network staff and MoRAP staff. A proposal for vegetation mapping was subsequently completed and approved by NPS National Vegetation Inventory Program staff. Based on that proposal, MoRAP was responsible for classification, plot sampling, mapping, and development of digital databases. The Heartland Network was responsible for oversight of MoRAP activities in concert with NPS Vegetation Inventory Program staff, and coordinated Accuracy Assessment (AA) tasks. PIPE staff provided logistical and technical support, and helped coordinate field activities.

Field Survey

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

Digital soil survey information, surface geology maps, and both current and historic air photos were initially reviewed, along with existing vegetation information (James 2011). A rapid field assessment, including collection of georeferenced field points, was made during the fall of 2011. Together, this body of information was used to plan quantitative field data collection (Figure 3). Observation points consisted of brief visits (fewer than 15 minutes) by ecologists from MoRAP where general information on vegetation structure and composition was noted.

Vegetation data were collected at 35 plots by MoRAP staff in June of 2012 (Figure 4). In the lab, the locations of plots were randomly placed within the following general strata based on field observation points and viewing of air photos and digital soils surveys (available at http://soildatamart.nrcs.usda.gov/): bur oak woodland and savanna, bottomland forest, typic deep-soil prairie, false indigo bush shrubland, smooth sumac shrubland, shallow-soiled quartzite prairie, and restored tallgrass prairie. Plots were located >30 m from an obvious land cover edge, and for each potential plot location there was at least one alternate, should the original point be determined unusable in the field (e.g. close to an un-mapped trail or road, stand too small). The stratified random plot location information was loaded into a GPS and workers navigated to the plot in the field for field sampling.

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

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

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

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

Table 1. Canopy Cover used for quantitative sampling.

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

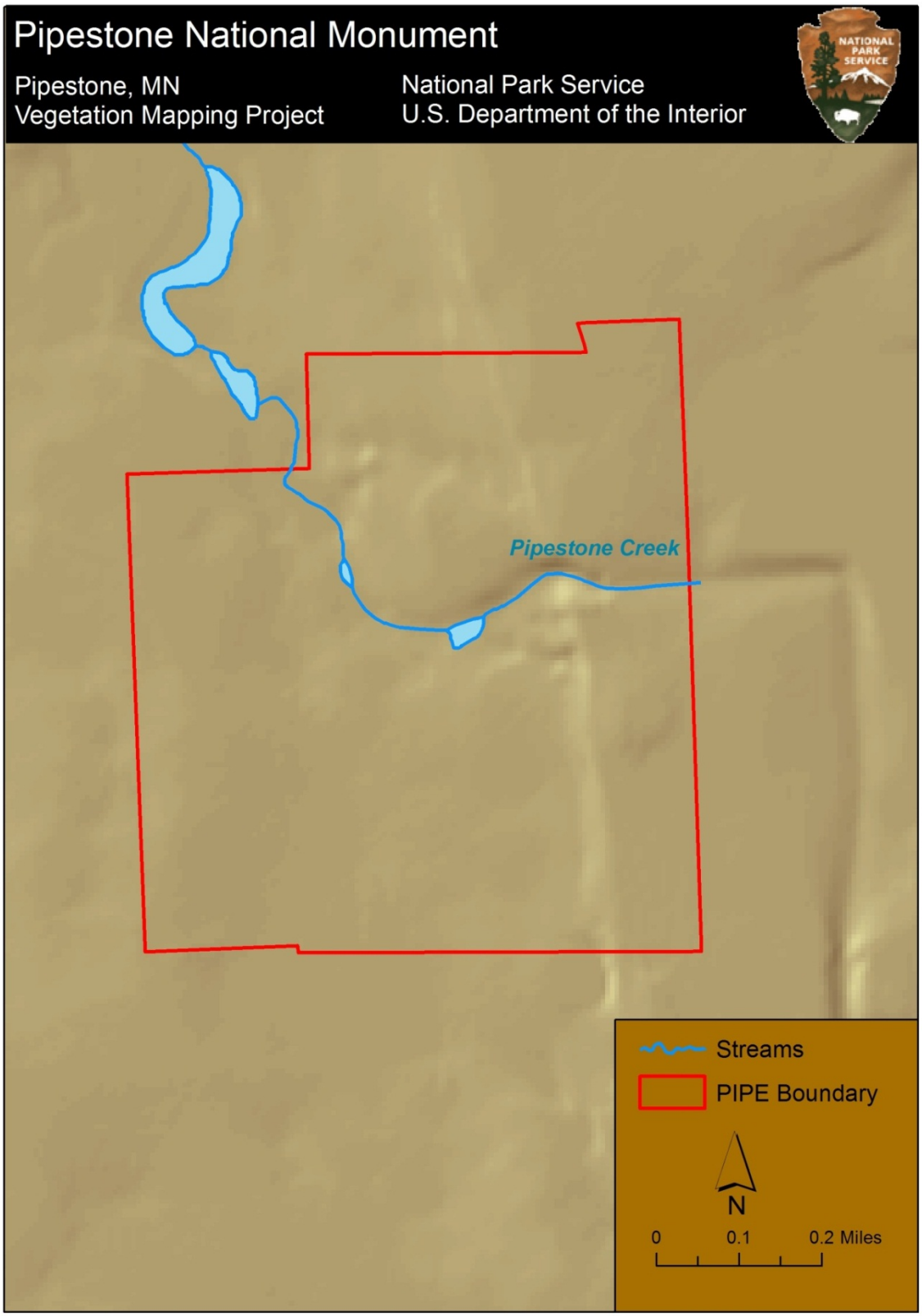


Figure 2. Map of the Pipestone National Monument.

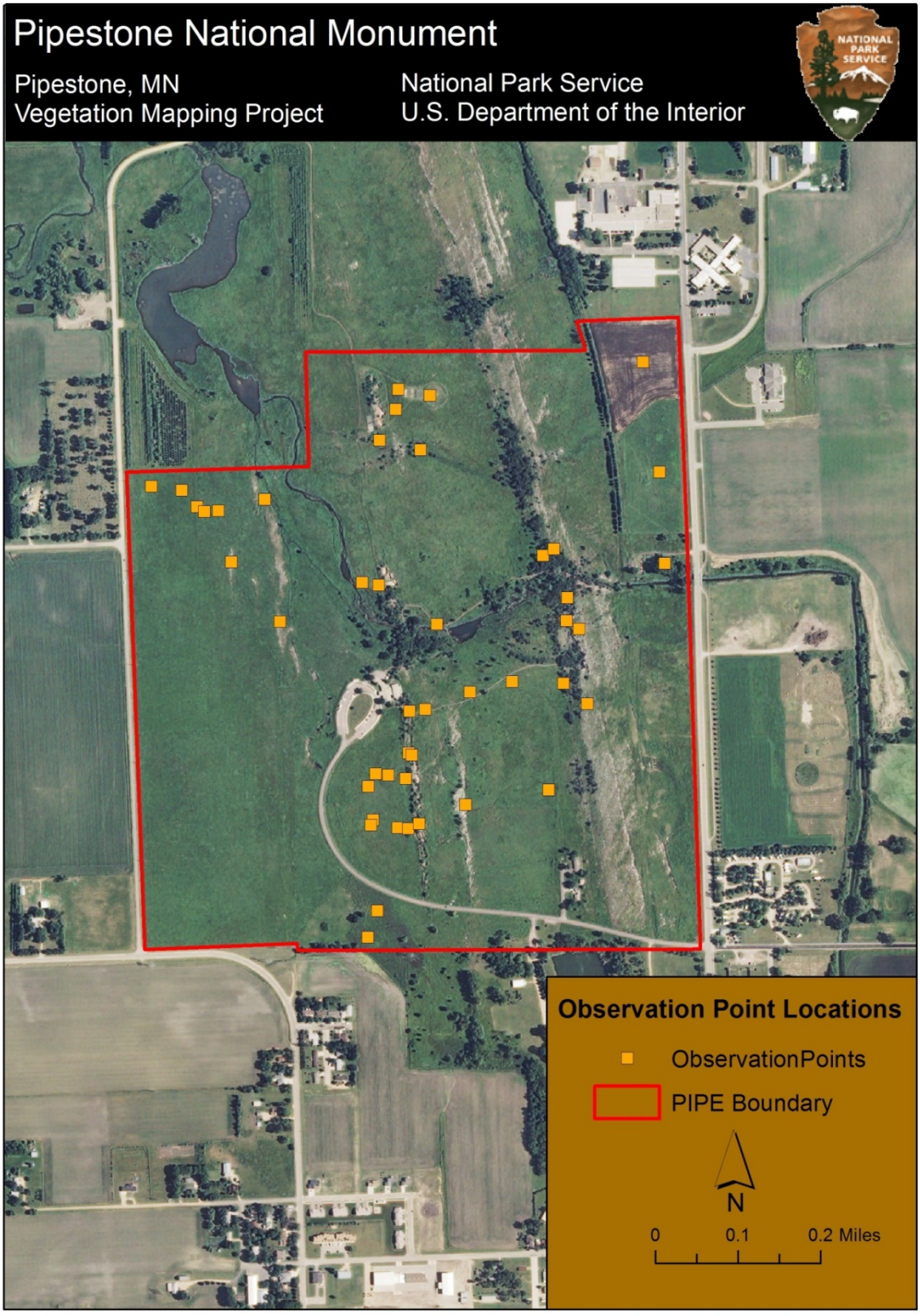


Figure 3. Location of 46 observation points collected in Pipestone National Monument.

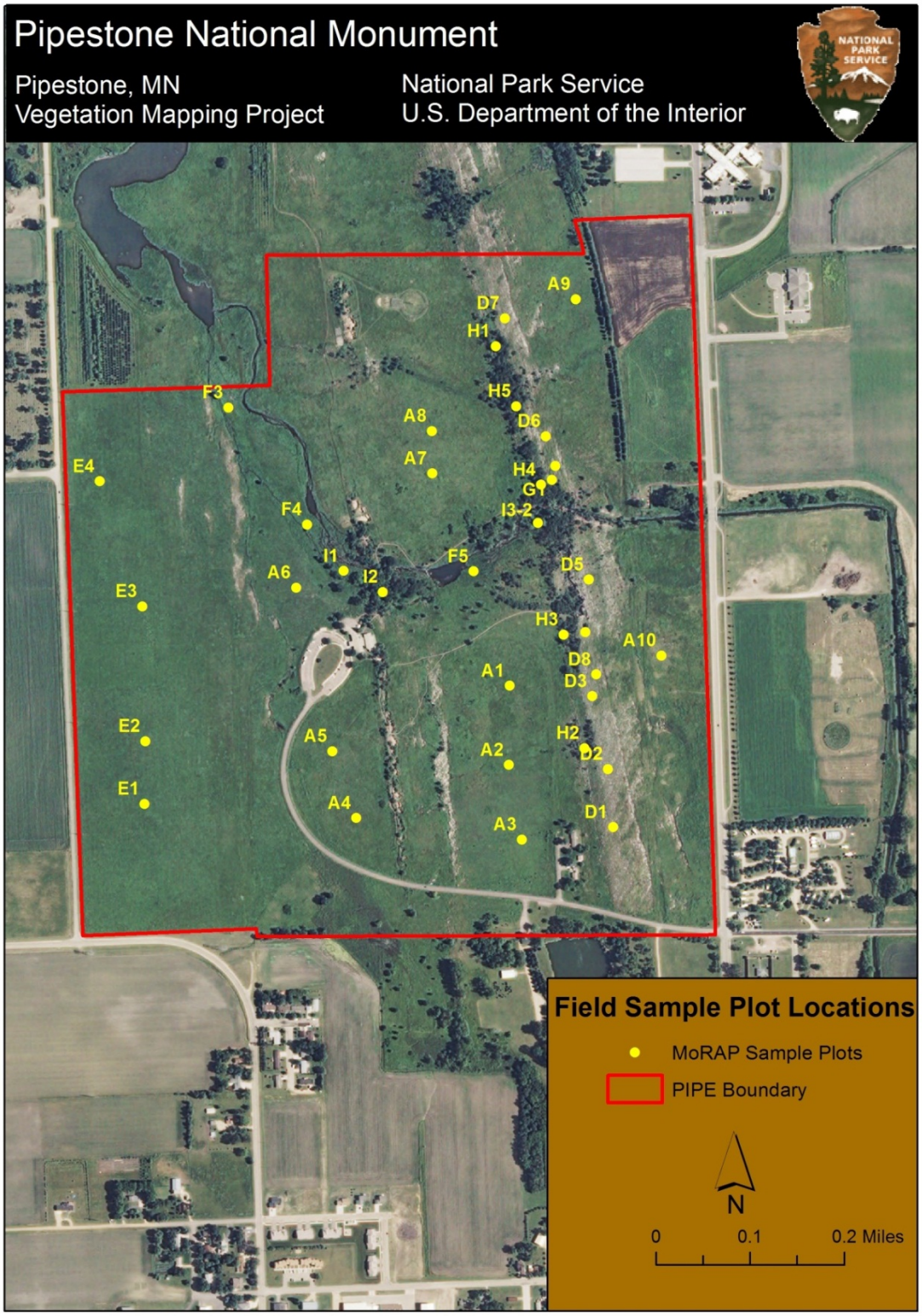


Figure 4. Location of 35 sampled plots within Pipestone National Monument.

Vegetation Classification

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

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

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

Use of this formula reduces the effects of overlapping cover in various strata. We used a log transformation to standardize cover values using the formula log(cover + 1). Bray-Curtis dissimilarity was used as the distance metric for the cluster and ordination analyses (Legendre and Legendre 1998). Clustering was performed using the hierarchical clustering algorithm known as flexible Beta with a $\beta = -0.25$ (Lance and Williams 1967, Maechler et al. 2011). Non-metric multidimensional scaling was used to develop the ordination (Legendre and Legendre 1998, Roberts 2010).

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

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

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

Digital Imagery and Interpretation

The mapping component was produced by identifying land cover on air photos and hand digitizing on-screen. Heads-up digitizing was accomplished at a display scale of not more than

1:1,000 against a back-drop of air photos. Imagery was the most recent available from the National Agriculture Imagery Program (NAIP; see http://www.fsa.usda.gov/Internet/FSA_File/naip_2009_info_final.pdf). This included 2010 leaf-on true color and 2006 leaf-on color infrared images. The historic black and white photos from 1938 and 1968 showed the location of former croplands that have since been restored to tallgrass prairie, plus the location of former roads that have been removed and restored to native grasses. Former roads were avoided as potential sample plot locations (Figure 5).

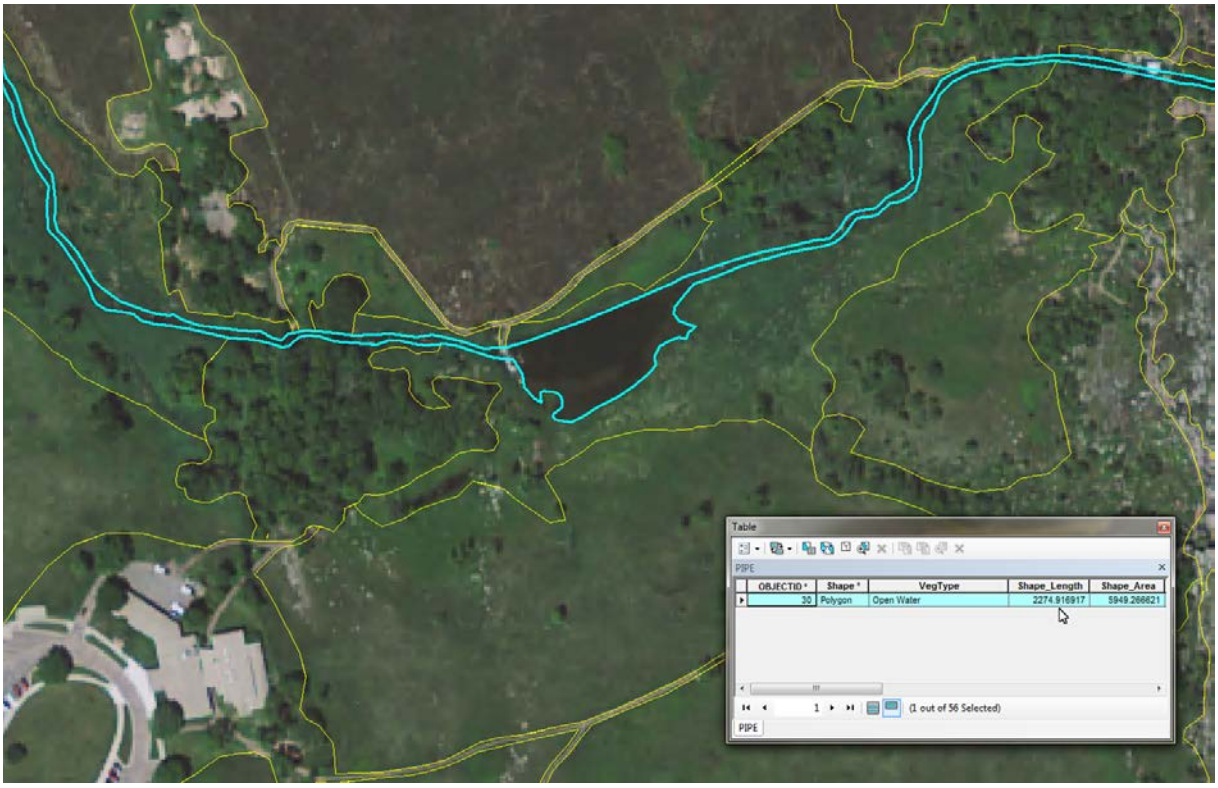


Figure 5. Digitization of hand drawn objects.

Accuracy Assessment

Thematic accuracy assessment was conducted by HTLN. Methods and analysis for the accuracy assessment of vegetation mapping at PIPE were based on NPS standards (Lea and Curtis 2010). Thematic accuracy assessment of mapped vegetation classes were assessed independently following the completion of the vegetation mapping inventory by the lead authors.

Representative sites were identified and visited in the field to determine if interpreted mapped classes were correctly assigned by field observers using the dichotomous key to mapped current vegetation types (Appendix C). Identifying the degree of correspondence between field observations and mapped attributes provides a measure of the map's suitability for different applications.

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

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

Scenario	Description	Polygons in class	Area occupied by class	Recommended number of samples in class
Scenario A:	The class is abundant. It covers more than 50 hectares of the total area and consists of at least 30 polygons. In this case, the recommended sample size is 30.	>30	>50 ha	30
Scenario B:	The class is relatively abundant. It covers more than 50 hectares of the total area but consists of fewer than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size for this type of class is that sample sites are more difficult to find because of the lower frequency of the class.	<30	>50 ha	20
Scenario C:	The class is relatively rare. It covers less than 50 hectares of the total area but consists of more than 30 polygons. In this case, the recommended sample size is 20. The rationale for reducing the sample size is that the class occupies a small area. At the same time, however, the class consists of a considerable number of distinct polygons that are possibly widely distributed. The number of samples therefore remains relatively high because of the high frequency of the class.	>30	<50 ha	20
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	5 - 30	<50 ha	5

Scenario	Description	Polygons in class	Area occupied by class	Recommended number of samples in class
	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.			
Scenario E:	The class is very rare. It has fewer than 5 polygons and occupies less than 50 hectares of the total area. In this case, it is recommended that the existence of the class be confirmed by a visit to each sample site. The rationale for the recommendation is that with fewer than 5 sample sites (assuming 1 site per polygon) no estimate of level of confidence can be established for the sample (the existence of the class can only be confirmed through field checking).	<5	<50 ha	Visit all and confirm

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

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

Plot shape and size varied according to the extent of the vegetation class patch containing the sample point. Circular 0.25 hectare (28 m radius) plots were used for larger patches while circular 0.1 hectare (18 m radius) plots were used for small patches approaching the minimum mapping unit. A circular plot size of 0.5 hectare (40 m radius) was used to capture information for a single large homogenous patch. In all cases, plot size exceeded the minimum patch size for PIPE.

Field staff recorded plot size and shape, positional accuracy and vegetation classification at each point (Accuracy assessment field form, Appendix D). In addition, comments regarding the plot location, plot size and vegetation were recorded on the field form. Field data from the 53 points were entered into to the PLOTS database and underwent quality assurance/quality control (QA/QC) verification. In addition, the associated project geodatabase was updated in ArcGIS to reflect any changes to the point location due to offsets made in the field. All classification and spatial field observations were compared with the vegetation map and AA point locations for any differences.

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

Table 3. Summary of the Accuracy Assessment statistics used at Pipestone National Monument.

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

Figure 6. Accuracy Assessment points for the Pipestone National Monument, including 3 unsampled points on rocky outcrops.

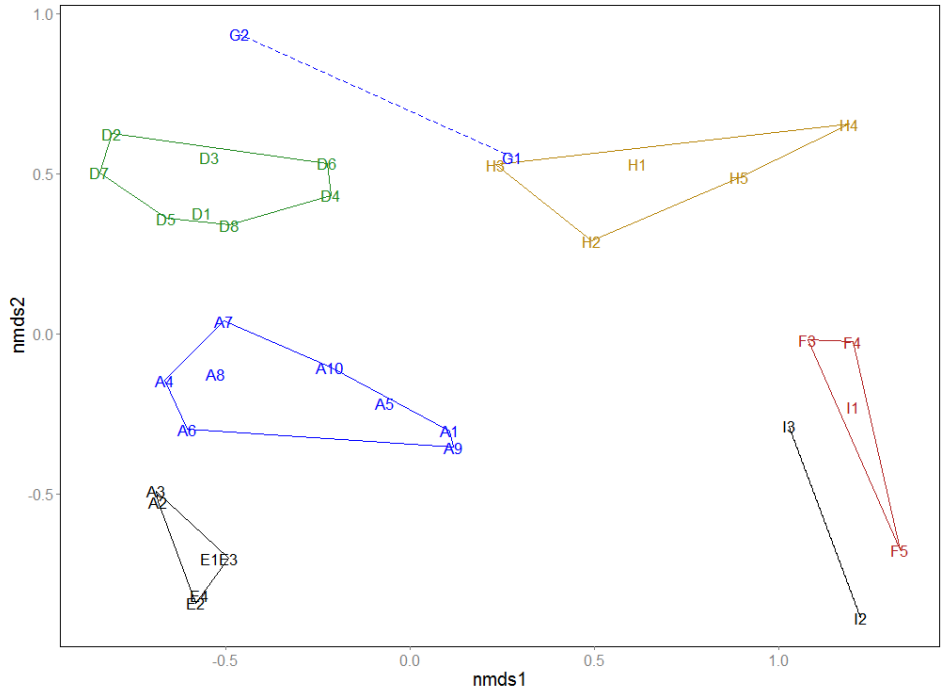
Results

Vegetation Classification

Seven vegetation types were identified at PIPE based on ordination and cluster analysis results (Figure 7). Three more types, including Reed Canarygass Western Herbaceous Vegetation (weedy or non-natural at PIPE), Disturbance Grassland (see type descriptions), and Failed Prairie Restoration (largely dominated by broadleaf forbs, see type descriptions), were identified based on field observation and viewing of air photos. Developed land, undivided by type, made up an 11th class, and cliff/bare rock outcrop made up a 12th class. During the sampling efforts a total of 170 taxa were recorded (Appendix E).

Green – Northern Tallgrass Quartzite Outcrop
Black (left) – Restored Tallgrass Prairie
Blue (top) – Smooth Sumac Ruderal Shrubland
Blue (Lower) – Central Mesic Tallgrass Prairie
Orange – Bur Oak Woodland
Black (right) – Northern Ash-Elm Floodplain Forest
Red – False Indigo Bush Ruderal Shrubland

Plots A2 and A3 were ambiguous in terms of classification, but they were physically located within the Central Mesic Tallgrass Prairie polygons, and their composition included a wider diversity of prairie forbs than those that represented the Restored Tallgrass Prairie. Prairie dropseed (Sporobolus heterolepis), which was absent from all four plots in the Restored Tallgrass Prairie, was among the dominant species in both of these plots. Therefore, for purposes of data summary, they were included within the Central Mesic Tallgrass Prairie type.



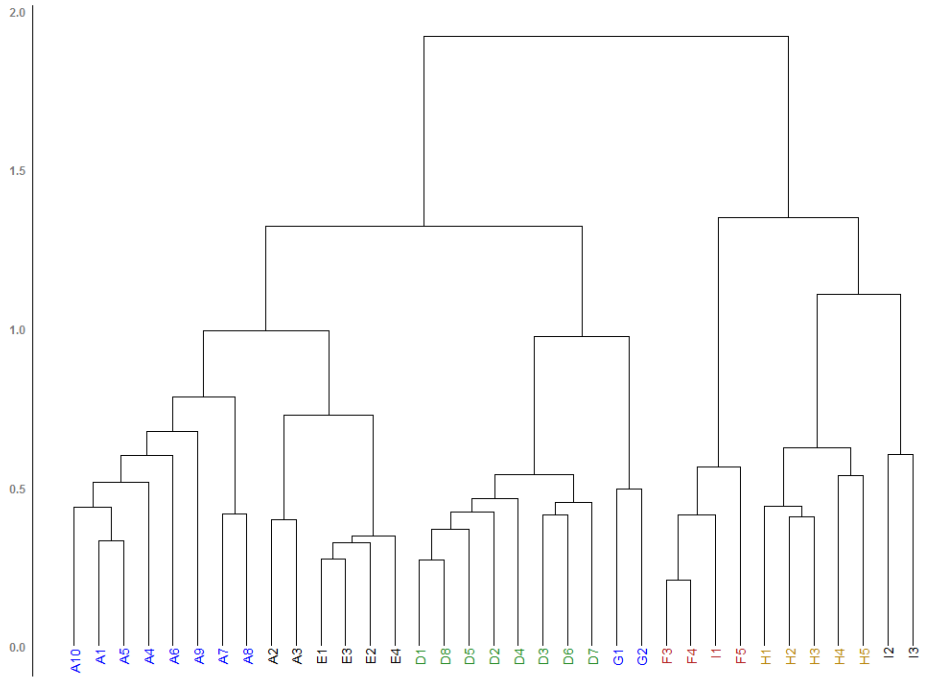


Figure 7. Ordination analysis and cluster dendogram.

Digital Imagery and Interpretation

Twelve terrestrial map units that corresponded directly with the classified vegetation plus developed land and cliff/bare rock outcrop were defined (Table 4). The developed land map class was a catch-all that included all areas without semi-natural vegetation.

Vegetation Map

A total of 294.7 acres (119.3 hectares) are within the accepted boundaries of PIPE (Figure 8). The standard minimum mapping unit for NPS vegetation mapping projects is defined as 0.5 hectare, although several mapped polygons were smaller for PIPE. Central Mesic Tallgrass Prairie made up 57.3% of the vegetated area of the monument, and dominated the view shed (157.1 acres; 63.6 hectares). The Restored Tallgrass Prairie made up another 24.4% of the monument, and was continuous with Central Mesic Tallgrass Prairie. Northern Tallgrass Quartzite Outcrop vegetation formed an essentially continuous, narrow belt along the length of a Sioux quartzite outcrop, including the lip of the rim of a bluff in some areas, and made up 5.4% of the monument. Bur Oak Woodland occurred below the bluff and occupied 1.9% of the park. A small Northern Ash-Elm Floodplain Forest occurred along the drainage of Pipestone Creek, as did False Indigo Bush Ruderal Shrubland, and these riparian types together made up about 5% of the area. Other types within the monument were associated with retirement from rowcrop agriculture or human use and disturbance, and together made up less than 5% of the area.

Accuracy Assessment

The 2012 accuracy assessment for PIPE was limited to the 294.7 acres (119.3 hectares) of natural and semi-natural vegetation within the park boundary. A total of 53 points were required to accurately evaluate the ten natural and semi-natural vegetation map classes identified in the

park. Navigational error (positional accuracy) of the GPS unit ranged from 2 – 3 meters for the 53 accuracy assessment points. The three points occurring on rocky outcrops were not sampled.

Table 4. Mapped types identified at Pipestone National Monument.

NVC Identifier	Mapped Type Name	Scientific Name / Description	Number of Polygons	Acres	Hectares
Forest and Woodlands					
CEGL002158	Bur Oak Woodland	*Quercus macrocarpa* Northern Tallgrass Wooded Herbaceous Vegetation	5	5.4	2.2
CEGL002081	Northern Ash-Elm Floodplain Forest	*Fraxinus pennsylvanica - Celtis occidentalis - Tilia americana - (Quercus macrocarpa)* Forest	4	2.9	1.2
Shrubland Vegetation					
None assigned	False Indigo Bush Ruderal Shrubland	*Amorpha fruticosa* Shrubland	7	10.4	4.2
None assigned	Smooth Sumac Ruderal Shrubland	*Rhus glabra* Shrubland	3	1.3	.5
Herbaceous Vegetation					
CEGL002202	Central Mesic Tallgrass Prairie	*Andropogon gerardii - Hesperostipa spartea - Sporobolus heterolepis* Herbaceous Vegetation	13	156.9	63.5
None assigned	Disturbance Grassland	*Bromus inermis - Oligoneuron rigidum - Achillea millefolium - Elymus repens - Cirsium* spp. Herbaceous Vegetation	2	3.5	1.4
None assigned	Failed Prairie Restoration	*Elymus repens - Ambrosia artemisiifolia - Trifolium pratense - Cirsium* spp. Herbaceous Vegetation	1	7.1	2.9
CEGL002298	Northern Tallgrass Quartzite Outcrop	Quartzite-Granite Rock Outcrop Sparse Vegetation	4	14.8	6.0
CEGL001417	Reed Canarygrass Western Herbaceous Vegetation	*Phalaris arundinacea* Western Herbaceous Vegetation	3	4.5	1.8
None assigned	Restored Tallgrass Prairie	*Andropogon gerardii* Herbaceous Vegetation	2	66.3	26.8
Land Use/Land Cover					
	Cultural		7	18.5	7.5
	Open Water		1	1.5	.6
	Rock Outcrop or Bluff (unsampled)		3	1.6	.6
Total Land Use/Land Cover			12	21.6	8.7
Total Natural Vegetation			44	273.1	110.5
Totals			**55**	**294.7**	**119.2**

Overall accuracy of the final error matrix was 97.9% (the 90% confidence interval was between 96.5 and 99.3%) for the natural and semi-natural mapped vegetation types at PIPE (Appendix A). Omission accuracy (map producer's error) exceeded 80% for all but two of the map classes.

A single point for both Northern Ash - Elm Floodplain Forest and Bur Oak Woodland were misclassified, thus resulting in omission accuracy's of 66.9% and 68.9%, respectively. Commission accuracy (user's error) exceeded 80% for all but three map classes. A single point mapped as Northern Ash-Elm Floodplain Forest was misclassified in the field as was a single point mapped as Smooth Sumac Ruderal Shrubland. The Reed Canarygrass Western Herbaceous Vegetation map class had the lowest commission accuracy of all ten map classes with 33.3%. In the field, two additional sites were determined to be included in this map class (the points were originally mapped as False Indigo Bush Ruderal Shrubland). Of the 53 accuracy assessment points, 47 were assigned correctly. Kappa Index, or the random chance polygons were assigned correctly, was 86% (Appendix A).

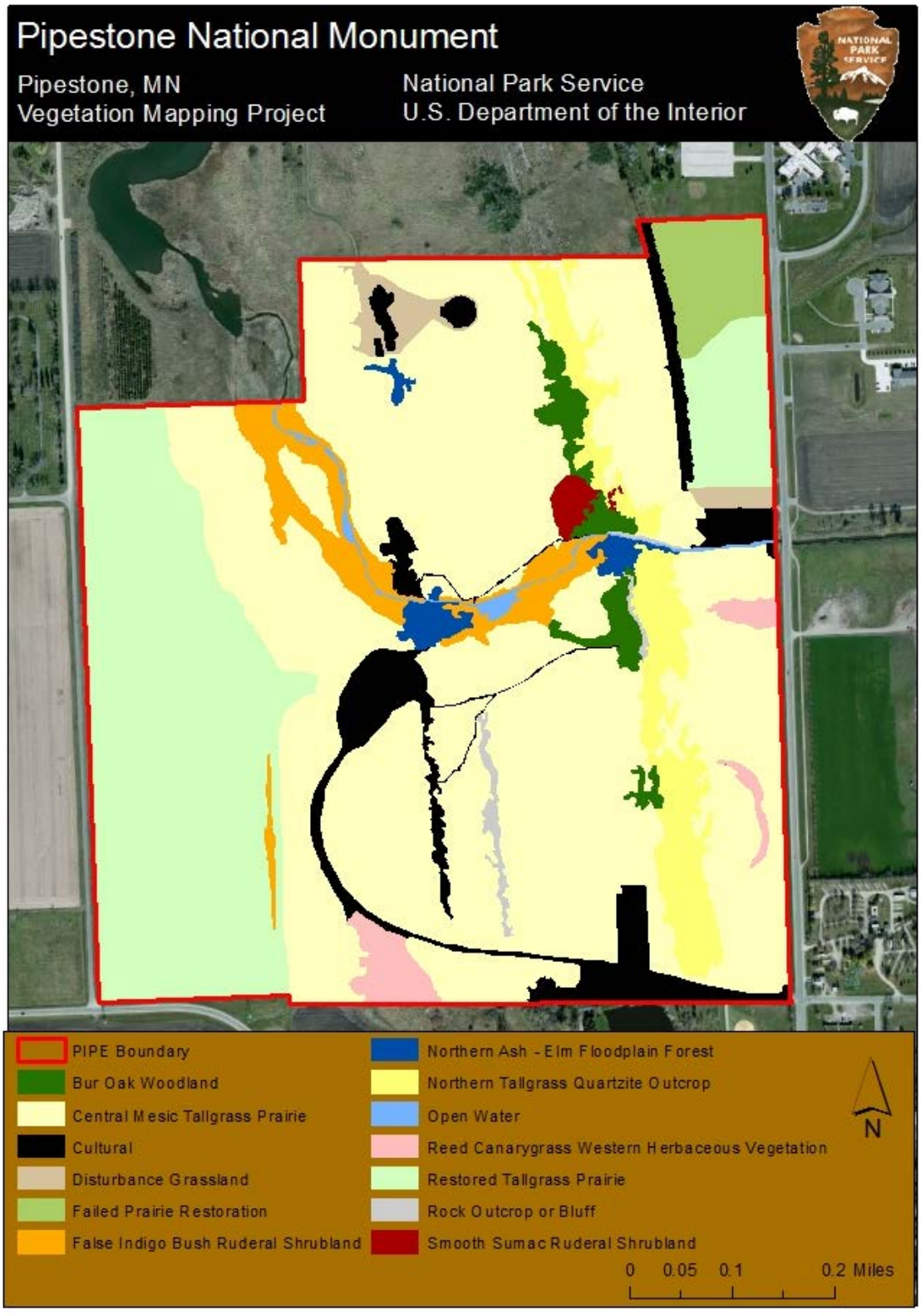


Figure 8. Vegetation map of Pipestone National Monument.

Vegetation Associations

Mapped Type Name: Bur Oak Woodland

Macrogroup: M012. Central Oak-Hardwood & Pine Forest
Group: G158. Northeastern & North Central Oak-Hickory Forest Group
Association: CEGL002158
Type Common Name: Northern Bur Oak Opening
Type Scientific Name: *Quercus macrocarpa* Northern Tallgrass Wooded Herbaceous Vegetation

Figure 9. Bur Oak Woodland at Pipestone National Monument.

Global Summary: This group is found throughout the glaciated regions of the Midwest, typically in rolling uplands. It forms a mosaic with tallgrass prairie communities in some landscapes. The type ranges from dry-mesic to dry, which distinguishes it from more mesic forest types in the Midwest. Common dominant species include white oak (*Quercus alba*), northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), pignut hickory (*Carya glabra*), and shagbark hickory (*Carya ovata*). Bur oak (*Quercus macrocarpa*) is a common component in the upper Midwest (Figure 9). American chestnut (*Castanea dentata*) was a common dominant before chestnut blight eliminated this species as a canopy component.

Environmental Description: At PIPE, this type occurred on the downslope side of the Sioux quartzite bluff that bisects the park from north to south on the eastern side. Soils are rocky and moist.

Vegetation Description: Bur oak was the prevailing dominant of this type, and often the only tree present, although common hackberry (*Celtis occidentalis*) was important in one of five plots sampled. Shrubs were present but generally not important overall, with common buckthorn (*Rhamnus cathartica*) and western snowberry (*Symphoricarpos occidentalis*) most dominant. Smooth brome (*Bromus inermis*) was the prevailing dominant of the herbaceous layer, possibly as a result of past grazing pressure. James' sedge (*Carex jamesii*) and Kentucky bluegrass (*Poa pratensis*) were also important in the herbaceous layer (Table 5).

Most Abundant Species:

Table 5. Species found in one or more of five plots within the Bur Oak Woodland vegetation type.

Bur Oak Woodland			
Scientific Name	**Common Name**	**Frequency**	**%Cover**
Tree Layer			
Celtis occidentalis	common hackberry	20%	15.0
Quercus macrocarpa	bur oak	80%	56.3
Shrub Layer			
Celastrus scandens	American bittersweet	20%	15.0
Celtis occidentalis	common hackberry	40%	0.5
Fraxinus pennsylvanica	green ash	40%	1.8
Juniperus virginiana	eastern redcedar	40%	0.5
Parthenocissus vitacea	woodbine	80%	1.1
Prunus americana	American plum	60%	1.3
Quercus macrocarpa	bur oak	80%	0.5
Rhamnus cathartica	common buckthorn	100%	1.5
Rhus glabra	smooth sumac	20%	0.5
Rubus occidentalis	black raspberry	20%	0.5
Smilax lasioneura	Blue Ridge carrionflower	20%	0.5
Spiraea alba	white meadowsweet	20%	0.5
Symphoricarpos occidentalis	western snowberry	100%	3.9
Toxicodendron radicans	eastern poison ivy	60%	11.0
Ulmus pumila	Siberian elm	20%	0.5
Herbaceous Layer			
Ambrosia artemisiifolia	annual ragweed	80%	1.1
Ambrosia psilostachya	Cuman ragweed	80%	0.5
Amorpha canescens	leadplant	60%	2.2
Artemisia ludoviciana	white sagebrush	60%	0.5
Asclepias syriaca	common milkweed	40%	0.5
Bromus inermis	smooth brome	100%	47.5

Bur Oak Woodland			
Scientific Name	**Common Name**	**Frequency**	**%Cover**
Carex jamesii	James' sedge	80%	14.0
Chenopodium album	lambsquarters	100%	0.5
Conyza canadensis	Canadian horseweed	60%	0.5
Cystopteris fragilis	brittle bladderfern	60%	0.5
Elymus repens	quackgrass	60%	5.3
Erigeron strigosus	prairie fleabane	40%	0.5
Erysimum cheiranthoides	wormseed wallflower	40%	0.5
Euthamia gymnospermoides	Texas goldentop	40%	0.5
Hackelia virginiana	beggarslice	40%	0.5
Hesperostipa spartea	porcupinegrass	40%	0.5
Lepidium densiflorum	common pepperweed	80%	0.5
Menispermum canadense	common moonseed	60%	0.5
Mirabilis nyctaginea	heartleaf four o'clock	100%	1.0
Nepeta cataria	catnip	60%	0.5
Oligoneuron rigidum var. *rigidum*	stiff goldenrod	40%	0.5
Oxalis stricta	common yellow oxalis	80%	0.5
Parietaria pensylvanica	Pennsylvania pellitory	100%	1.5
Poa compressa	Canada bluegrass	40%	0.5
Poa pratensis	Kentucky bluegrass	80%	8.4
Polygonum scandens	climbing false buckwheat	60%	0.5
Portulaca oleracea	little hogweed	40%	0.5
Schizachyrium scoparium	little bluestem	40%	0.5
Silene stellata	widowsfrill	80%	0.5
Solidago gigantea	giant goldenrod	80%	0.5
Sporobolus heterolepis	prairie dropseed	40%	1.8
Stachys tenuifolia	smooth hedgenettle	40%	0.5
Thalictrum thalictroides	rue anemone	40%	0.5
Tragopogon dubius	yellow salsify	60%	0.5
Verbascum thapsus	common mullein	40%	0.5
Viola nephrophylla	northern bog violet	60%	0.5

Mapped Type Name: Central Mesic Tallgrass Prairie

Macrogroup: M054. Great Plains Tallgrass Prairie & Shrubland
Group: G075. Northern Great Plains Tallgrass Prairie Group
Association: CEGL002202
Type Common Name: Central Mesic Tallgrass Prairie
Type Scientific Name: *Andropogon gerardii - Hesperostipa spartea - Sporobolus heterolepis* Herbaceous Vegetation

Figure 10. Central Mesic Tallgrass Prairie in Pipestone National Monument.

Global Summary: This type circumscribes tallgrass communities throughout the Upper Midwest from the Red River Valley in Minnesota north into southern Manitoba. It is the northern extension of the "true prairie" group of communities. Big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) are often among the dominants (Figure 10). This group represents generally drier grassland communities versus those to the south within the true prairie.

Environmental Description: This type occupied both relatively deep and relatively shallow soils at PIPE, but all areas appeared to be unbroken native sod. Variation due to soils and drainage were superimposed on variation due to past disturbance (e.g. grazing), and sampling failed to reveal differences caused by abiotic site type that could be distinguished, classified, and mapped.

Vegetation Description: Big bluestem was the prevailing dominant within this type, and other native grasses including porcupinegrass (*Hesperostipa spartea*), switchgrass, little bluestem (*Schizachyrium scoparium*), and prairie dropseed were important. Two non-natives, smooth brome and Kentucky bluegrass, were also among the most important grass species, and probably indicative of past grazing. A compliment of native prairie forbs were also present, including leadplant (*Amorpha canescens*, a sub-shrub), Maximilian sunflower (*Helianthus maximiliani*),

stiff goldenrod (*Oligoneuron rigidum* var. *rigidum*), and white heath aster (*Symphyotrichum ericoides*)(Table 6).

Most Abundant Species:

Table 6. Species found in at least three of 10 plots within the Central Mesic Tallgrass Prairie vegetation type.

Central Tallgrass			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Shrub Layer			
Prunus americana	American plum	30%	6.2
Rosa arkansana	prairie rose	100%	1.8
Herbaceous Layer			
Ambrosia psilostachya	Cuman ragweed	60%	1.8
Amorpha canescens	leadplant	80%	4.4
Andropogon gerardii	big bluestem	100%	22.8
Anemone canadensis	Canadian anemone	40%	0.5
Apocynum cannabinum	Indianhemp	40%	0.5
Artemisia ludoviciana	white sagebrush	50%	3.9
Asclepias syriaca	common milkweed	70%	1.6
Bromus inermis	smooth brome	80%	34.3
Calystegia sepium	hedge false bindweed	40%	0.5
Dichanthelium oligosanthes	Heller's rosette grass	70%	0.5
Glycyrrhiza lepidota	American licorice	40%	1.1
Helianthus maximiliani	Maximilian sunflower	30%	2.2
Helianthus nuttallii	Nuttall's sunflower	40%	1.8
Helianthus tuberosus	Jerusalem artichoke	50%	0.5
Hesperostipa spartea	porcupinegrass	80%	8.9
Liatris punctata	dotted blazing star	30%	0.5
Monarda fistulosa	wild bergamot	40%	2.4
Oligoneuron rigidum var. *rigidum*	stiff goldenrod	50%	3.4
Panicum virgatum	switchgrass	70%	0.5
Pediomelum argophyllum	silverleaf Indian breadroot	60%	0.9
Phlox paniculata	fall phlox	50%	0.5
Physalis virginiana	Virginia groundcherry	40%	0.5
Poa pratensis	Kentucky bluegrass	100%	9.6
Ratibida pinnata	pinnate prairie coneflower	40%	0.5
Schizachyrium scoparium	little bluestem	60%	7.5
Solidago canadensis	Canada goldenrod	60%	1.3
Solidago gigantea	giant goldenrod	40%	0.5
Solidago missouriensis	Missouri goldenrod	50%	1.5
Solidago nemoralis	gray goldenrod	40%	1.1
Sporobolus heterolepis	prairie dropseed	90%	9.8

Central Tallgrass			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Symphyotrichum ericoides	white heath aster	70%	1.2
Symphyotrichum lanceolatum	white panicle aster	40%	0.5

Mapped Type Name: Disturbance Grassland

Macrogroup: M123. Eastern North American Ruderal Shrubland & Grassland
Group: G059. Northern & Central Ruderal Meadow & Shrubland Group
Association: None
Type Common Name: Disturbance Grassland
Type Scientific Name: *Bromus inermis - Oligoneuron rigidum - Achillea millefolium - Elymus repens - Cirsium* spp. Herbaceous Vegetation

Global Summary: This group circumscribes a wide variety of shrub or herb meadows in the northern and central regions of the eastern United States. Introduced grasses that have been planted or volunteer into old fields dominate this type, with species such as smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and timothy (*Phleum pratense*) common dominants. Shrubs may or may not be present, and generally account for less than 25% of the total cover. Common shrubs include dogwood species (*Cornus* spp.), sumac species (*Rhus* spp.), blackberries (*Rubus* spp.), and eastern redcedar (*Juniperus virginiana*). Non-native species commonly include multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonicas*), and Russian olive (*Elaeagnus angustifolia*).

Environmental Description: At PIPE, this type was mapped in two patches, both of which show signs of regular mowing or tromping for human use. Past and on-going disturbance, rather than abiotic site characteristics, controlled the distribution of this type.

Vegetation Description: This type was dominated by smooth brome together with a variety of weedy herbaceous species, including common yarrow (*Achillea millefolium*), quackgrass (*Elymus repens*), and thistle species (*Cirsium* spp.).

Most Abundant Species:

No quantitative data were taken within this mapped type.

Mapped Type Name: Failed Prairie Restoration

Macrogroup: M123. Eastern North American Ruderal Shrubland & Grassland
Group: G059. Northern & Central Ruderal Meadow & Shrubland Group
Association: None
Type Common Name: Failed Prairie Restoration
Type Scientific Name: *Elymus repens - Ambrosia artemisiifolia - Trifolium pratense - Cirsium* spp. Herbaceous Vegetation

Global Summary: This group circumscribes a wide variety of shrub or herb meadows in the northern and central regions of the eastern United States. Introduced grasses that have been planted or volunteer into old fields dominate this type, with species such as smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and timothy (*Phleum pratense*) dominant. Shrubs may or may not be present, and generally account for less than 25% of the total cover. Common shrubs include dogwood species (*Cornus* spp.), sumac species (*Rhus* spp.), blackberries (*Rubus* spp.), and eastern redcedar (*Juniperus virginiana*). Non-native species commonly include multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonicas*), and Russian olive (*Elaeagnus angustifolia*).

Environmental Description: At PIPE, this type was mapped in a single patch that represented an old field where prairie restoration was attempted but failed due to unfavorable environmental conditions after planting. Past and on-going disturbance, rather than abiotic site characteristics, controlled the distribution of this type.

Vegetation Description: This type was dominated by very early successional grasses and forbs, including quackgrass (*Elymus repens*), annual ragweed (*Ambrosia artemisiifolia*), red clover (*Trifolium pratense*), and thistle species (*Cirsium* spp.). This site is likely to change rapidly either due to plant succession of management actions.

Most Abundant Species:

No quantitative data were taken within this mapped type.

Mapped Type Name: False Indigo Bush Ruderal Shrubland
Macrogroup: M071. Great Plains Wet Meadow, Wet Prairie & Marsh
Group: G337. Great Plains shrub & Herb Riparian Group
Association: None
Type Common Name: False Indigo Bush Ruderal Shrubland
Type Scientific Name: *Amorpha fruticosa* Shrubland

Figure 11. False Indigo Bush Ruderal Shrubland at Pipestone National Monument.

Global Summary: This group circumscribes a wide variety of herb or shrub dominated wetlands within the Great Plains. Sites may be on raised islands within river floodplains, along streams, or at the margins of water bodies. Areas are generally flooded periodically. Dominant species may include dogwood species (*Cornus* spp.), buttonbush (Cephalanthus *occidentalis*), and chokecherry (*Prunus virginiana*). Kentucky bluegrass (*Poa pratensis*) is often an important grass (Figure 11). Examples of this type may occur on a floodplain interspersed with Great Plains Floodplain Forest Group communities.

Environmental Description: At PIPE this type occurred primarily along Pipestone Creek in wet to moist, frequently flooded soils. A small, linear patch associated with a ditch along a former (restored) road bed occurred on the west side of the monument.

Vegetation Description: False indigo bush (*Amorpha fruticosa*) was the prevailing dominant of this type and formed nearly monodominant stands in some places. Reed canarygrass (*Phalaris arundinacea*) was present and important in all four plots sampled within this type. Smooth

brome (*Bromus inermis*) was also important and among the dominants in three of four plots (Table 7). The overall composition, which included a number of non-native and weedy species, was indicative of past or on-going disturbance, possibly due to fairly high-flow or frequent flooding.

Most Abundant Species:

Table 7. Species found in one or more of four plots within the False Indigo Bush Ruderal Shrubland vegetation type.

False Indigo Bush			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Shrub Layer			
Amorpha fruticosa	false indigo bush	100%	28.9
Ribes missouriense	Missouri gooseberry	25%	0.5
Herbaceous			
Apocynum cannabinum	Indianhemp	25%	0.5
Artemisia ludoviciana	white sagebrush	50%	0.5
Asclepias ovalifolia	oval-leaf milkweed	25%	0.5
Asclepias syriaca	common milkweed	50%	1.8
Bromus inermis	smooth brome	75%	62.5
Elymus repens	quackgrass	25%	0.5
Galium aparine	stickywilly	25%	0.5
Helianthus grosseserratus	sawtooth sunflower	25%	0.5
Heracleum maximum	common cowparsnip	25%	0.5
Mirabilis nyctaginea	heartleaf four o'clock	25%	0.5
Oxalis stricta	common yellow oxalis	25%	0.5
Phalaris arundinacea	reed canarygrass	100%	35.1
Poa pratensis	Kentucky bluegrass	25%	0.5
Prunella vulgaris	common selfheal	25%	0.5
Solidago gigantea	giant goldenrod	50%	0.5
Stachys tenuifolia	smooth hedgenettle	25%	0.5
Taraxacum officinale	common dandelion	25%	0.5
Urtica dioica	stinging nettle	75%	0.5

Mapped Type Name: Northern Ash – Elm Floodplain Forest

Macrogroup: M029. Northern & Central Floodplain Forest & Scrub
Group: G040. Silver Maple-Green Ash-Sycamore Floodplain Group
Association: CEGL002081
Type Common Name: Ash – Elm – Mixed Lowland Hardwood Forest
Type Scientific Name: *Fraxinus pennsylvanica - Celtis occidentalis - Tilia americana -* (*Quercus macrocarpa*) Forest

Figure 12. Northern Ash – Elm Floodplain Forest at Pipestone National Monument.

Global Summary: This group circumscribes floodplain forests of eastern North America. They are dominated by some combination of silver maple (*Acer saccharinum*), sycamore (*Platanus occidentalis*), hackberry species (*Celtis* spp.), American elm (*Ulmus americana*), and river birch (*Betula nigra*) (Figure 12). Vines are common within this type, and the herbaceous layer often features an abundance of spring ephemerals. Most representatives of this type are under water each spring, and microtopography influences composition of all layers.

Environmental Description: At PIPE, this type was limited to small patches along drainages, primarily along Pipestone Creek. Soils were moist to wet and these areas can be briefly flooded, especially after heavy rainfall events in the spring.

Vegetation Description: This type was dominated by green ash (*Fraxinus pennsylvanica*) and boxelder (*Acer negundo*). Bur oak (*Quercus macrocarpa*), sandbar willow (*Salix interior*), and common hackberry (*Celtis occidentalis*) were also present in the overstory. Boxelder was also

important in the shrub layer, and woodbine (*Parthenocissus vitacea*) and eastern poison ivy (*Toxicodendron radicans*) were common vines. Canada wildrye (*Elymus canadensis*), northern bog violet (*Viola nephrophylla*), and stinging nettle (*Urtica dioica*) were important in the herbaceous layer. Reed canarygrass (*Phalaris arundinacea*), a weedy, invasive species, was important in patches (Table 8).

Most Abundant Species:

Table 8. Species that occurred in one or both plots within the Northern Ash-Elm Floodplain Forest Vegetation type.

Northern Ash-Elm Floodplain Forest			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Tree Layer			
Acer negundo	boxelder	100%	20.3
Celtis occidentalis	common hackberry	50%	3.0
Fraxinus pennsylvanica	green ash	100%	26.3
Quercus macrocarpa	bur oak	50%	15.0
Salix interior	sandbar willow	50%	15.0
Shrub Layer			
Acer negundo	boxelder	100%	7.8
Celtis occidentalis	common hackberry	50%	0.5
Fraxinus pennsylvanica	green ash	100%	0.5
Parthenocissus vitacea	woodbine	100%	1.8
Quercus macrocarpa	bur oak	50%	0.5
Rhamnus cathartica	common buckthorn	100%	0.5
Ribes missouriense	Missouri gooseberry	50%	0.5
Salix interior	sandbar willow	50%	0.5
Symphoricarpos occidentalis	western snowberry	50%	0.5
Toxicodendron radicans	eastern poison ivy	50%	0.5
Vitis riparia	riverbank grape	50%	0.5
Herbaceous Layer			
Agrostis scabra	rough bentgrass	50%	0.5
Ambrosia trifida	great ragweed	100%	0.5
Arctium minus	lesser burdock	50%	0.5
Asclepias ovalifolia	oval-leaf milkweed	50%	0.5
Asclepias syriaca	common milkweed	50%	0.5
Calystegia sepium	hedge false bindweed	100%	0.5
Elymus canadensis	Canada wildrye	50%	37.5
Erigeron strigosus	prairie fleabane	50%	0.5
Hackelia virginiana	beggarslice	50%	0.5
Heracleum maximum	common cowparsnip	100%	0.5
Leonurus cardiaca	common motherwort	100%	0.5
Maianthemum racemosum	feathery false lily of the valley	50%	0.5

Northern Ash-Elm Floodplain Forest			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Menispermum canadense	common moonseed	50%	0.5
Phalaris arundinacea	reed canarygrass	50%	15.0
Physalis virginiana	Virginia groundcherry	50%	0.5
Plantago major	common plantain	50%	0.5
Rumex crispus	curly dock	100%	0.5
Sanicula odorata	clustered blacksnakeroot	50%	0.5
Smilax herbacea	smooth carrionflower	50%	0.5
Solidago gigantea	giant goldenrod	100%	0.5
Stachys tenuifolia	smooth hedgenettle	50%	0.5
Symphyotrichum lateriflorum var. *lateriflorum*	calico aster	50%	0.5
Taraxacum officinale	common dandelion	50%	0.5
Thalictrum thalictroides	rue anemone	100%	0.5
Urtica dioica	stinging nettle	100%	1.8
Vernonia fasciculata	prairie ironweed	50%	0.5
Viola nephrophylla	northern bog violet	100%	7.8
Zizia aurea	golden zizia	50%	0.5

Mapped Type Name: Northern Tallgrass Quartzite Outcrop

Macrogroup: M116. Great Plains Cliff, Scree & Rock Vegetation
Group: G567. Great Plains Cliff, Scree & Rock Vegetation Group
Association: CEGL002298
Type Common Name: Northern Tallgrass Quartzite – Granite Rock Outcrop
Type Scientific Name: Quartzite-Granite Rock Outcrop Sparse Vegetation

Figure 13. Northern Tallgrass Quartzite Outcrop at Pipestone National Monument.

Global Summary: This group circumscribes a variety of cliffs, bluffs, and rock outcrops in the Great Plains from the U.S.-Canada border south to Texas. The defining characteristic is sparse vegetation rather than plant species composition. Exposed rock is generally sedimentary, but the expression in southwestern Minnesota is formed by Sioux quartzite (Figure 13). Soil accumulates in pockets or cracks in rock and short grasses such as gramas (*Bouteloua* spp.) and cacti (*Opuntia* spp.) are common components.

Environmental Description: This type occurred as a prominent, relatively flat Sioux quartzite outcrop at PIPE, often on the upland side of a quartzite bluff that runs north to south on the eastern side of the monument. Soils were shallow and dry, and have developed in cracks within the rock or as pockets. Adjacent deeper soils were within the Central Mesic Tallgrass Prairie vegetation type, and the transition zone between the two types, while not entirely distinct, tended to occur over short distances (e.g. 30 feet; 9.1 meters).

Vegetation Description: A wide diversity of herbaceous species shared dominance within this type. Porcupinegrass (*Hesperostipa spartea*), Kentucky bluegrass (*Poa pratensis*), little bluestem (*Schizachyrium scoparium*), and prairie dropseed (*Sporobolus heterolepis*) were among the most frequent and dominant grasses. Buffalograss (*Bouteloua dactyloides*), blue grama (*Bouteloua gracilis*), plains muhly (*Muhlenbergia cuspidata*), and prairie Junegrass (*Koeleria macrantha*) were common grasses within this type that were seldom encountered in other communities. Other common species included rough false pennyroyal (*Hedeoma hispida*), sunbright (*Phemeranthus parviflorus*), Canada bluegrass (*Poa compressa*), and northern selaginella (*Selaginella rupestris*) (Table 9).

Most Abundant Species:

Table 9. Species found within at least three of eight plots within the Northern Tallgrass Quartzite Outcrop vegetation type.

Northern Tallgrass Quartzite			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Shrub Layer			
Rosa arkansana	prairie rose	50%	0.5
Herbaceous Layer			
Agrostis scabra	rough bentgrass	75%	0.5
Ambrosia psilostachya	Cuman ragweed	75%	1.3
Amorpha canescens	leadplant	100%	4.8
Andropogon gerardii	big bluestem	100%	2.7
Artemisia frigida	prairie sagewort	38%	0.5
Bouteloua curtipendula	sideoats grama	75%	1.3
Bouteloua dactyloides	buffalograss	88%	1.9
Bouteloua gracilis	blue grama	75%	2.2
Bromus arvensis	field brome	63%	1.0
Bromus inermis	smooth brome	63%	12.3
Comandra umbellata	bastard toadflax	38%	0.5
Conyza canadensis	Canadian horseweed	38%	0.5
Dichanthelium oligosanthes	Heller's rosette grass	100%	0.5
Erigeron strigosus	prairie fleabane	63%	0.5
Hedeoma hispida	rough false pennyroyal	88%	0.5
Hesperostipa spartea	porcupinegrass	100%	0.8
Koeleria macrantha	prairie Junegrass	100%	1.4
Lepidium densiflorum	common pepperweed	50%	0.5
Muhlenbergia cuspidata	plains muhly	75%	0.9
Opuntia fragilis	brittle pricklypear	75%	0.5
Oxalis stricta	common yellow oxalis	63%	0.5
Pascopyrum smithii	western wheatgrass	75%	0.9
Phemeranthus parviflorus	sunbright	88%	0.5
Plantago patagonica	woolly plantain	63%	0.5

Northern Tallgrass Quartzite			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Poa compressa	Canada bluegrass	88%	3.3
Poa pratensis	Kentucky bluegrass	100%	10.2
Polygonum ramosissimum	bushy knotweed	50%	0.5
Potentilla arguta	tall cinquefoil	38%	0.5
Schizachyrium scoparium	little bluestem	100%	13.3
Selaginella rupestris	northern selaginella	100%	0.8
Silene antirrhina	sleepy silene	50%	0.5
Solidago missouriensis	Missouri goldenrod	75%	0.5
Solidago nemoralis	gray goldenrod	38%	0.5
Sporobolus compositus	composite dropseed	38%	2.2
Sporobolus heterolepis	prairie dropseed	100%	11.8
Symphyotrichum ericoides	white heath aster	50%	0.5
Symphyotrichum oblongifolium	aromatic aster	75%	0.5
Tragopogon dubius	yellow salsify	75%	0.5

Mapped Type Name: Reed Canarygrass Western Herbaceous Vegetation

Macrogroup: M301. Western North American Wet Meadow & Marsh
Group: G524. Western North American Ruderal Wet Meadow & Marsh Group
Association: CEGL001474
Type Common Name: Reed Canarygrass Western Herbaceous Vegetation
Type Scientific Name: *Phalaris arundinacea* Western Herbaceous Vegetation

Global Summary: This herbaceous community occurs throughout western North America and eastward into the Great Plains and Central Lowlands. Reed canarygrass grows as a ruderal species in moist soils, including areas that may be flooded for extended periods. The vegetation is characterized by a dense, tall herbaceous layer, where reed canarygrass tends to form monocultures. Introduced and weedy species tend to be associated with this type. Common associated species include field horsetail (*Equisetum arvense),* scratchgrass *(Muhlenbergia asperifolia),* wild mint *(Mentha arvensis),* smooth brome *(Bromus inermis),* cheatgrass *(Bromus tectorum),* quackgrass *(Elymus repens),* and Kentucky bluegrass *(Poa prantensis).*

Environmental Description: At PIPE, this type occurred in three small patches over disturbed, moist soils.

Vegetation Description: The patches representing this type at PIPE are often nearly monodominant stands of reed canarygrass (*Phalaris arundinacea*). Active management is on-going to try to reduce the abundance of this species at PIPE.

Most Abundant Species:

No quantitative data were taken within this mapped type.

Mapped Type Name: Restored Tallgrass Prairie

Macrogroup: None
Group: None
Association: None
Type Common Name: Restored Tallgrass Prairie
Type Scientific Name: *Andropogon gerardii* Herbaceous Vegetation

Figure 14. Restored Tallgrass Prairie at Pipestone National Monument.

Global Summary: Tallgrass prairie restorations have been attempted throughout the former tallgrass prairie region. The restoration at PIPE is typical of these efforts. Some combination of big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*) are typically dominant in restorations (Figure 14). Both native and non-native grasses and forbs tend to volunteer into areas that have been planted with prairie grasses and forbs. Typically, grasses dominate these sites with a limited complement of native prairie forbs. Culms of dominate grasses reach more than 6 feet (2 meters) in the fall, and provide a prairie-like aspect. On-going efforts are required to maintain and enhance prairie restorations, both to reduce unwanted species and enhance the compliment of native prairie forbs and grasses.

Environmental Description: At PIPE, this type occurs on mesic but well-drained soils that were once in row crop production.

Vegetation Description: Big bluestem was the prevailing dominant of this type, which appeared quite uniform in aspect and low in forb diversity, in contrast with the adjacent Central Mesic Tallgrass Prairie vegetation type. Other important species included Canada goldenrod (*Solidago canadensis*), leadplant (*Amorpha canescens*), Maximilian sunflower (*Helianthus maximiliani*), switchgrass, Kentucky bluegrass (*Poa pratensis*), and Indiangrass. Prairie rose *(Rosa arkansana*) was present in all four plots within this type. Porcupinegrass (*Hesperostipa spartea*) and prairie dropseed (*Sporobolus heterolepis*), which were common and important within the Central Mesic Tallgrass prairie type, were absent from plots within this type (Table 10).

Most Abundant Species:

Table 10. Species found within one or more of four plots within the Restored Tallgrass Prairie vegetation type.

Restored Tallgrass Prairie			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Shrub Layer			
Fraxinus pennsylvanica	green ash	25%	0.5
Rosa arkansana	prairie rose	100%	1.75
Ulmus americana	American elm	25%	0.5
Herbaceous Layer			
Achillea millefolium	common yarrow	25%	0.5
Amorpha canescens	leadplant	75%	2.17
Andropogon gerardii	big bluestem	100%	43.75
Anemone canadensis	Canadian anemone	50%	0.5
Apocynum cannabinum	Indianhemp	25%	0.5
Asclepias syriaca	common milkweed	75%	0.5
Bromus inermis	smooth brome	25%	0.5
Dalea candida	white prairie clover	75%	0.5
Dalea purpurea	purple prairie clover	75%	0.5
Dichanthelium oligosanthes	Heller's rosette grass	25%	0.5
Erigeron philadelphicus	Philadelphia fleabane	25%	0.5
Galium boreale	northern bedstraw	25%	3
Glycyrrhiza lepidota	American licorice	50%	1.75
Helianthus maximiliani	Maximilian sunflower	100%	1.75
Helianthus nuttallii	Nuttall's sunflower	50%	0.5
Juncus interior	inland rush	25%	0.5
Liatris aspera	tall blazing star	25%	0.5
Oligoneuron rigidum var. *rigidum*	stiff goldenrod	25%	0.5
Panicum virgatum	switchgrass	100%	1.75
Phlox paniculata	fall phlox	25%	0.5
Physalis virginiana	Virginia groundcherry	25%	0.5
Poa pratensis	Kentucky bluegrass	100%	15
Potentilla arguta	tall cinquefoil	25%	0.5

Restored Tallgrass Prairie			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Pycnanthemum tenuifolium	narrowleaf mountainmint	25%	0.5
Ratibida pinnata	pinnate prairie coneflower	25%	0.5
Rudbeckia hirta	blackeyed Susan	25%	0.5
Schizachyrium scoparium	little bluestem	50%	0.5
Solidago canadensis	Canada goldenrod	100%	12
Solidago gigantea	giant goldenrod	25%	0.5
Sorghastrum nutans	Indiangrass	50%	1.75
Symphyotrichum ericoides	white heath aster	50%	0.5
Symphyotrichum laeve	smooth blue aster	100%	0.5
Carex spp.	sedge	75%	0.5
Zizia aurea	golden zizia	25%	0.5

Mapped Type Name: Smooth Sumac Ruderal Shrubland

Macrogroup: M124. Eastern North American Ruderal Shrubland & Grassland
Group: Northern & Central Ruderal Meadow & Shrubland Group
Association: None
Type Common Name: Smooth Sumac Ruderal Shrubland
Type Scientific Name: *Rhus glabra* Ruderal Shrubland

Figure 15. Smooth Sumac Ruderal Shrubland in Pipestone National Monument.

Global Summary: This group circumscribes a wide variety of shrub or herb dominated meadows in the northern and central regions of the eastern United States. Grasses, forbs, ferns, small trees, and shrubs may dominate. Areas within this group have often been cleared or plowed. A wide variety of plants may dominate. Goldenrods (*Solidago* spp.) are common. Grasses may include Kentucky bluegrass (*Poa pratensis*), quackgrass (*Elymus repens*), and smooth brome (*Bromus inermis*). A wide variety of shrubs or small trees may occur, including pines (*Pinus* spp.), eastern redcedar (*Juniperus virginiana*), multiflora rose (*Rosa multiflora*), and sumacs (*Rhus* spp.) (Figure 15).

Environmental Description: At PIPE, this type represented prairie areas over presumably unbroken native sod that have been invaded by smooth sumac (*Rhus glabra*). Areas within this type occurred both above the Sioux quartzite outcrop over relatively shallow soils and below the outcrop over relatively deep soils.

Vegetation Description: Smooth sumac was the only shrub recorded within plots representing this type. This species is considered somewhat weedy, but is native and often is a component of disturbed native grasslands. Important herbaceous species included the introduced grasses, smooth brome and Kentucky bluegrass, along with native grasses including porcupinegrass (*Hesperostipa spartea*), and little bluestem (*Schizachyrium scoparium*) (Table 11).

Most Abundant Species:

Table 11. Species found in one or both plots within the Smooth Sumac Ruderal Shrubland vegetation type.

Smooth Sumac			
Scientific Name	**Common Name**	**Frequency**	**% Cover**
Shrub Layer			
Rhus glabra	smooth sumac	100%	73.8
Herbaceous Layer			
Ambrosia artemisiifolia	annual ragweed	100%	0.5
Ambrosia psilostachya	Cuman ragweed	100%	0.5
Amorpha canescens	leadplant	100%	0.5
Andropogon gerardii	big bluestem	50%	0.5
Bouteloua gracilis	sideoats grama	50%	0.5
Bromus inermis	smooth brome	50%	37.5
Chenopodium album	lambsquarters	50%	0.5
Dichanthelium oligosanthes	Heller's rosette grass	50%	0.5
Hedeoma hispida	rough false pennyroyal	50%	0.5
Helianthus nuttallii	Nuttall's sunflower	50%	0.5
Hesperostipa spartea	porcupinegrass	50%	15.0
Lepidium densiflorum	common pepperweed	50%	0.5
Mirabilis nyctaginea	heartleaf four o'clock	50%	0.5
Oxalis stricta	common yellow oxalis	50%	0.5
Pascopyrum smithii	western wheatgrass	50%	3.0
Phemeranthus parviflorus	sunbright	50%	0.5
Poa compressa	Canada bluegrass	50%	0.5
Poa pratensis	Kentucky bluegrass	100%	26.3
Schizachyrium scoparium	little bluestem	50%	3.0
Selaginella rupestris	northern selaginella	50%	0.5
Silene antirrhina	sleepy silene	50%	0.5
Solidago missouriensis	Missouri goldenrod	100%	0.5
Solidago nemoralis	gray goldenrod	50%	0.5
Taraxacum officinale	common dandelion	50%	0.5

Discussion

The landscape of PIPE includes areas of unbroken sod that were large enough to provide a prairie aspect, together with a quartzite outcrop and a bluff that runs north to south across the length of the monument and featured a narrow bur oak (*Quercus macrocarpa*) woodland on the downslope side and a quartzite grassland over the rock outcrop upslope. These features are punctuated by Pipestone Creek, which supported a small floodplain forest and riparian shrublands. The importance of the relatively natural grassland communities at PIPE has long been recognized (see James 2011). However, all areas at PIPE appeared to have been grazed in the past, and non-native species, especially smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*), were components of the prairie grasslands.

We stratified samples at PIPE so plots were placed over very shallow quartzite-influenced soils, and over both shallow and deep unbroken prairie soils. Results clearly showed differences between the Tallgrass Prairie and Quartzite Outcrop communities, but did not reveal differences due to soil depth within the Central Mesic Tallgrass Prairie community. This may have been due to the influence of past grazing in terms of homogenizing current composition due to the presence of grazing tolerant species in most plots, over all soil types.

Field Survey

The Failed Prairie Restoration will likely be a target for restoration, and hence monitoring seems particularly appropriate within this type. Documentation of dynamics and response to management within all communities via repeated quantitative sampling will be highly desirable.

NVC Classification

Five types at PIPE fit within National Vegetation Classification (NVC) concepts, and quantitative data from PIPE will add to the knowledge of variation within these types. The Northern Tallgrass Quartzite Outcrop community is fairly unique to Minnesota, and Sioux quartzite is not widespread. Data from this type will add to the knowledge of the type. The False Indigo Bush and Smooth Sumac Ruderal Shrubland types are not described within the NVC, so data from PIPE may be used to help define these associations. The Restored Tallgrass Prairie is typical of prairie restorations throughout the Midwest, even though each is somewhat unique. The Disturbance Grassland and Failed Prairie Restoration types seem specific to PIPE, and might not be worthy of further consideration within the NVC.

Digital Imagery and Interpretation

Multiple years of imagery were available for the park and were used to develop map polygons. The use of historic air photos clearly revealed areas that were formerly plowed, and allowed accurate delineation of the Restored Tallgrass Prairie where it was continuous with Central Mesic Tallgrass Prairie over unbroken sod. Because the park was small, heads up digitizing of polygons that represent the classified types was possible.

Accuracy Assessment

Overall thematic accuracy of the vegetation mapping inventory met the required threshold. The park is dominated by two prairie map classes that account for 81.5% of the mapped vegetation. All map classes were sampled according to Scenario E except for Central Mesic Tallgrass Prairie

map class which followed Scenario B. Thus nine of the 10 map classes occupied fewer small polygons. The Northern Ash-Elm Floodplain Forest map class is distributed along the westward flowing Pipestone Creek. This class intersects the Bur Oak Woodland map class which runs north and south through the park parallel to the rock outcrop formations. Their discontinuous canopy led to misclassification where the two types intersected. Two isolated polygons originally mapped as False Indigo Bush Ruderal Shrubland were easily identified as Reed Canarygrass Western Herbaceous Vegetation and updated on the map. With nine rare map classes identified across the park, field staff was able to visit all polygons and assess thematic accuracy. For all vegetation map classes, the dichotomous key allowed for clear identification at the majority of points.

Future Recommendations

The prairie and woodland communities at PIPE that occurred over unbroken native sod are uncommon in the tallgrass prairie region, and are worthy of on-going management and monitoring. Efforts to restore prairie and to reduce the abundance of undesired species within the prairie community are already underway (see James 2011). The False Indigo Bush Ruderal Shrubland that occurred mainly along Pipestone Creek may be the result of past flooding events, and this type could be quite dynamic over time, so monitoring seems appropriate. Reed canarygrass occurred in several patches and was considered weedy at PIPE. Efforts to control this species are on-going. Smooth brome and Kentucky bluegrass are likewise considered undesirable, but were currently integral parts of the grassland communities at PIPE, and deserve management attention. Finally, the northern patch of Disturbance Grassland occurred within a matrix of unbroken native sod. The impact of further human disturbance of this area, and impacts on adjacent grasslands, are worthy of management and monitoring concern.

Research Opportunities

Restoration of tallgrass prairie on former croplands, and management of unbroken sod to control undesirable species, will be among the most important on-going activities with regard to natural resources at PIPE. The communities at PIPE are relatively large, and experiments to help define the most effective management actions to enhance grasslands could be designed and implemented on site. Western prairie fringed orchid (*Platanthera praeclara*) grows within the Central Mesic Tallgrass Prairie, and management and monitoring of this species of conservation concern is on-going (Young and Haack 2009). Finally, the Northern Tallgrass Quartzite Outcrop community at PIPE is fairly extensive and is quite unique and species-rich. Botanical or ecological investigations of this community might be worthy of pursuit.

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Appendix A: Contingency Table for Vegetation Mapping of Pipestone National Monument.

	Reference Data (Accuracy Assessment Field Data)											User's Error			
Sample Data (Polygon Map Data)	Map Units	False Indigo Bush Ruderal Shrubland	Northern Ash - Elm Floodplain Forest	Bur Oak Woodland	Reed Canarygrass Western Herbaceous Vegetation	Disturbance Grassland	Northern Tallgrass Quartzite Outcrop	Restored Tallgrass Prairie	Failed Prairie Restoration	Smooth Sumac Ruderal Shrubland	Central Mesic Tallgrass Prairie	Totals	Commission Accuracy	90% Conf. Interval	
														-	+
	False Indigo Bush Ruderal Shrubland	**6**		1								7	85.7%	56.8%	100.0%
	Northern Ash - Elm Floodplain Forest	1	**3**									4	75.0%	26.9%	100.0%
	Bur Oak Woodland		1	**4**								5	80.0%	40.6%	100.0%
	Reed Canarygrass Western Herbaceous Vegetation	2			**1**							3	33.3%	0.0%	94.8%
	Disturbance Grassland					**2**						2	100.0%	75.0%	100.0%
	Northern Tallgrass Quartzite Outcrop						**4**					4	100.0%	87.5%	100.0%
	Restored Tallgrass Prairie							**5**				5	100.0%	90.0%	100.0%
	Failed Prairie Restoration								**1**			1	100.0%	50.0%	100.0%
	Smooth Sumac Ruderal Shrubland									**2**	1	3	66.7%	5.2%	100.0%
	Central Mesic Tallgrass Prairie										**19**	19	100.0%	97.4%	100.0%
	Totals	9	4	5	1	2	4	5	1	2	20				
Producer's Error	Omission Accuracy	81.0%	66.9%	68.9%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	**47 Total Correct Points**			
	90% Conf. -	79.7%	66.3%	68.1%	99.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	**53 Total Points**			
	Level +	82.3%	67.4%	69.7%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%				
Overall Total Accuracy =97.9% Overall Kappa Index =86.0% Overall 90% Upper and Lower Confidence Interval =96.5% and 99.3%															

Accuracy Assessment Contingency Table:

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

Appendix B: Example of Plot Survey Form

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

Plot Code _____ Surveyors _____
Date _____

Plot Directions

_____

Plot Dimensions _____ by _____ m Photos (y/n) _____
Provisional Community Name

_____

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

_____
_____
_____

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

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

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

Plot Shape (circle) concave convex flat irregular
General Comments

_____
_____
_____

Plot Code _____

NPS VEGETATION MAPPING PROGRAM – PLOT SURVEY FORM
VEGETATION SAMPLING

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

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

SPECIES COMPOSITION AND COVER CLASS BY STRATUM
%Cover (1=<1%, 2=1-5%, 3=5-25%, 4=25-50%, 5=50-75%, 6=75-95%, 7=95-100%)

T1	T2	T3	S1	S2	H	Species	Comments

Plot Code ___________

T1	T2	T3	S1	S2	H	Species	Comments

Appendix C: Pipestone National Monument Dichotomous Key to Mapped Current Vegetation Types

1a. Unvegetated rock outcrop or bluff >.25 ha .....**Rock Outcrop or Bluff**

1b. Community vegetated, or if bare rocks are exposed, these occur within a matrix of vegetation **2**

2a. Forest or woodland community with overstory trees >3 m tall present..... **3**

3a. Bottomland species such as green ash (*Franinus pennsylvanica*) or boxelder (*Acer negundo*) dominant; if bur oak (*Quercus macrocarpa*) present, this species shares dominance with bottomland trees..... **Northern Ash – Elm Floodplain Forest**

3b. Bur oak (*Quercus macrocarpa*) the dominant tree .....**Bur Oak Woodland**

2b. Grassland or shrubland community lacking overstory trees or trees limited to one or a few individuals within a grassland or shrubland matrix..... **4**

4a. Shrubland vegetation with shrubs >1 m tall, clearly emergent from the herbaceous layer, accounting for >20% total canopy cover **5**

5a. Smooth sumac (*Rhus glabra*) the dominant shrub..... .....**Smooth Sumac Ruderal Shrubland**

5b. False indigo bush (*Amorpha fruticosa*) the dominant shrub..... .....**False Indigo Bush Ruderal Shrubland**

4b. Herbaceous vegetation with few shrubs (<20% total canopy cover); emergent shrubs, if present, occur as small patches within a herbaceous matrix..... **6**

6a. Bare rocks present at surface and a mixture of native short- and mid-grasses, such as sideoats grama (*Bouteloua curtipendula),* blue grama (*Bouteloua gracilis),* buffalograss (*Bouteloua dactyloides)* and plains muhly (*Muhlenbergia cuspidata*) are important components .....**Northern Tallgrass Quartzite Outcrop**

6b. Bare rock, if present, occurs in a matrix of deeper soils..... **7**

7a. Vegetation dominated by reed canarygrass (*Phalaris arundinacea*) .... **Reed Canarygrass Western Herbaceous Vegetation**

7b. Vegetation not dominated by reed canarygrass (*Phalaris arundinacea*)..... **8**

8a. Vegetation with an open/sparse aspect but not showing signs of regular human use (mowing, tromping); dominated by ruderal forbs and grasses such as quackgrass (*Elymus repens*), annual ragweed (*Ambrosia artemisifolia*), red

clover (*Trifolium pratense*), and thistle (*Cirsium* spp.) ....**Failed Prairie Restoration**

8b. Vegetation dominated by grasses, or, if dominated by forbs, showing signs of regular human use (mowing, tromping) **9**

9a. Vegetation dominated by smooth brome (*Bromus inermis*) and other disturbance-tolerate species such as stiff goldenrod (*Oligoneuron rigidum*), common yarrow (*Achillea millefolium*), quackgrass (*Elymus repens*), and thistle (*Circium* spp); showing signs of regular human use (mowing, tromping) .....**Disturbance Grassland**

9b. Vegetation not dominated by smooth brome (*Bromus inermis*) and other disturbance-tolerant species; not showing signs of regular human use (mowing, tromping)..... **10**

10a. Vegetation strongly dominated by big bluestem (*Andropogon gerardii*) and with a homogeneous aspect; lacking or nearly lacking native grasses such as prairie dropseed (*Sporobolus heterolepis*) and porcupinegrass (*Hersperostipa spartea*) ……**Restored Tallgrass Prairie**

10b. Vegetation dominated by a mix of native grasses and forbs with a heterogeneous aspect; in addition to big bluestem (*Andropogon gerardii*), native grasses such as prairie dropseed (*Sporobolus heterolepis*), porcupinegrass (*Hersperostipa spartea*), and little bluestem (*Schizachyrium scoparium*) may be important ....**Central Mesic Tallgrass Prairie**

Appendix D: Example of Accuracy Assessment Form

Accuracy Assessment Form

NPS Vegetation Inventory

PLOT (WAYPOINT) #:_____ 2. DATE:_____

OBSERVER (DETERMING ASSOCIATION) _____

Observer (assisting) _____

ACCURACY OF NAVIGATION (METERS) _____

How Determined: _____

UTM EASTING: _____ 8. UTM: _____

9. UTM Zone: _____ 10. Datum: _____

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

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

b.) Physical constraints in reaching waypoint

c.) Other (explain as needed):_____

_____

_____

12. VEGETATION ASSOCIATION (Primary call): _____

_____

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

_____

14. Explanation for # 13 (if applicable): _____

_____

Appendix E: Species List for Pipestone National Monument

Family	Scientific Name	Common Name
Aceraceae	*Acer negundo*	boxelder
Anacardiaceae	*Rhus glabra*	smooth sumac
	Toxicodendron radicans	eastern poison ivy
Apiaceae	*Heracleum maximum*	common cowparsnip
	Sanicula odorata	clustered blacksnakeroot
	Zizia aurea	golden zizia
Apocynaceae	*Apocynum cannabinum*	Indianhemp
Asclepiadaceae	*Asclepias ovalifolia*	oval-leaf milkweed
	Asclepias syriaca	common milkweed
	Asclepias verticillata	whorled milkweed
Asteraceae	*Achillea millefolium*	common yarrow
	Ambrosia artemisiifolia	annual ragweed
	Ambrosia psilostachya	Cuman ragweed
	Ambrosia trifida	great ragweed
	Arctium minus	lesser burdock
	Artemisia frigida	prairie sagewort
	Artemisia ludoviciana	white sagebrush
	Aster sp.	aster
	Bidens sp.	beggarticks
	Brickellia eupatorioides	false boneset
	Conyza canadensis	Canadian horseweed
	Erechtites hieraciifolia	American burnweed
	Erigeron philadelphicus	Philadelphia fleabane
	Erigeron strigosus	prairie fleabane
	Euthamia gymnospermoides	Texas goldentop
	Helianthus grosseserratus	sawtooth sunflower
	Helianthus maximiliani	Maximilian sunflower
	Helianthus nuttallii	Nuttall's sunflower
	Helianthus tuberosus	Jerusalem artichoke
	Heliopsis helianthoides	smooth oxeye
	Liatris aspera	tall blazing star
	Liatris punctata	dotted blazing star
	Oligoneuron rigidum var. *rigidum*	stiff goldenrod
	Packera plattensis	prairie groundsel
	Ratibida pinnata	pinnate prairie coneflower
	Rudbeckia hirta	blackeyed Susan
	Solidago canadensis	Canada goldenrod

Family	Scientific Name	Common Name
Asteraceae	*Solidago gigantea*	giant goldenrod
	Solidago missouriensis	Missouri goldenrod
	Solidago nemoralis	gray goldenrod
	Symphyotrichum ericoides	white heath aster
	Symphyotrichum laeve	smooth blue aster
	Symphyotrichum lanceolatum	white panicle aster
	Symphyotrichum lateriflorum var. *lateriflorum*	calico aster
	Symphyotrichum oblongifolium	aromatic aster
	Taraxacum officinale	common dandelion
	Tragopogon dubius	yellow salsify
	Vernonia fasciculata	prairie ironweed
Boraginaceae	*Hackelia virginiana*	beggarslice
Brassicaceae	*Erysimum cheiranthoides*	wormseed wallflower
	Hesperis matronalis	dames rocket
	Lepidium densiflorum	common pepperweed
Cactaceae	*Opuntia fragilis*	brittle pricklypear
Caprifoliaceae	*Symphoricarpos occidentalis*	western snowberry
Caryophyllaceae	*Silene antirrhina*	sleepy silene
	Silene stellata	widowsfrill
Celastraceae	*Celastrus scandens*	American bittersweet
Chenopodiaceae	*Chenopodium album*	lambsquarters
Commelinaceae	*Tradescantia bracteata*	longbract spiderwort
Convolvulaceae	*Calystegia sepium*	hedge false bindweed
Cornaceae	*Cornus sericea*	redosier dogwood
Cupressaceae	*Juniperus virginiana*	eastern redcedar
Cyperaceae	*Carex* sp.	sedge
	Carex jamesii	James' sedge
	Eleocharis obtusa	blunt spikerush
Dryopteridaceae	*Cystopteris fragilis*	brittle bladderfern
Equisetaceae	*Equisetum laevigatum*	smooth horsetail
Euphorbiaceae	*Chamaesyce glyptosperma*	ribseed sandmat
	Euphorbia spathulata	warty spurge
Fabaceae	*Amorpha canescens*	leadplant
	Amorpha fruticosa	false indigo bush
	Astragalus canadensis	Canadian milkvetch
	Dalea candida	white prairie clover
	Dalea purpurea	purple prairie clover
	Glycyrrhiza lepidota	American licorice
Family	Scientific Name	Common Name

Family	Scientific Name	Common Name
Fabaceae	*Lathyrus venosus*	veiny pea
	Lotus unifoliolatus	American bird's-foot trefoil
	Melilotus officinalis	sweetclover
	Pediomelum argophyllum	silverleaf Indian breadroot
	Securigera varia	crownvetch
	Vicia americana	American vetch
Fagaceae	*Quercus macrocarpa*	bur oak
Grossulariaceae	*Ribes missouriense*	Missouri gooseberry
Juncaceae	*Juncus interior*	inland rush
Lamiaceae	*Hedeoma hispida*	rough false pennyroyal
	Leonurus cardiaca	common motherwort
	Monarda fistulosa	wild bergamot
	Nepeta cataria	catnip
	Prunella vulgaris	common selfheal
	Pycnanthemum tenuifolium	narrowleaf mountainmint
	Stachys tenuifolia	smooth hedgenettle
Liliaceae	*Asparagus officinalis*	garden asparagus
	Maianthemum racemosum ssp. *racemosum*	feathery false lily of the valley
Menispermaceae	*Menispermum canadense*	common moonseed
Nyctaginaceae	*Mirabilis nyctaginea*	heartleaf four o'clock
Oleaceae	*Fraxinus americana*	white ash
	Fraxinus pennsylvanica	green ash
Orchidaceae	*Platanthera praeclara*	Great Plains white fringed orchid
Oxalidaceae	*Oxalis stricta*	common yellow oxalis
	Oxalis violacea	violet woodsorrel
Plantaginaceae	*Plantago major*	common plantain
	Plantago patagonica	woolly plantain
Poaceae	*Agrostis scabra*	rough bentgrass
	Andropogon gerardii	big bluestem
	Aristida dichotoma	churchmouse threeawn
	Bouteloua curtipendula	sideoats grama
	Bouteloua dactyloides	buffalograss
	Bouteloua gracilis	blue grama
	Bromus arvensis	field brome
	Bromus inermis	smooth brome
	Dichanthelium oligosanthes	Heller's rosette grass
	Elymus canadensis	Canada wildrye

Family	Scientific Name	Common Name
Poaceae	*Elymus repens*	quackgrass
	Hesperostipa spartea	porcupinegrass
	Hordeum pusillum	little barley
	Koeleria macrantha	prairie Junegrass
	Muhlenbergia cuspidata	plains muhly
	Panicum virgatum	switchgrass
	Pascopyrum smithii	western wheatgrass
	Phalaris arundinacea	reed canarygrass
	Phleum pratense	timothy
	Poa compressa	Canada bluegrass
	Poa pratensis	Kentucky bluegrass
	Schizachyrium scoparium	little bluestem
	Sorghastrum nutans	Indiangrass
	Spartina pectinata	prairie cordgrass
	Sporobolus compositus var. *compositus*	composite dropseed
	Sporobolus heterolepis	prairie dropseed
	Sporobolus vaginiflorus	poverty dropseed
Polemoniaceae	*Phlox paniculata*	fall phlox
Polygonaceae	*Polygonum ramosissimum*	bushy knotweed
	Polygonum scandens	climbing false buckwheat
	Rumex crispus	curly dock
Portulacaceae	*Phemeranthus parviflorus*	sunbright
	Portulaca oleracea	little hogweed
Ranunculaceae	*Anemone canadensis*	Canadian anemone
	Delphinium carolinianum	Carolina larkspur
	Thalictrum thalictroides	rue anemone
Rhamnaceae	*Rhamnus cathartica*	common buckthorn
Rosaceae	*Fragaria virginiana*	Virginia strawberry
	Potentilla arguta	tall cinquefoil
	Potentilla pensylvanica	Pennsylvania cinquefoil
	Prunus americana	American plum
	Prunus pumila	sandcherry
	Rosa arkansana	prairie rose
	Rubus occidentalis	black raspberry
	Spiraea alba	white meadowsweet
Rubiaceae	*Galium aparine*	stickywilly
	Galium boreale	northern bedstraw
	Galium obtusum	bluntleaf bedstraw
Salicaceae	*Salix interior*	sandbar willow
Santalaceae	*Comandra umbellata*	bastard toadflax

Family	Scientific Name	Common Name
Saxifragaceae	*Heuchera richardsonii*	Richardson's alumroot
Scrophulariaceae	*Verbascum thapsus*	common mullein
	Veronicastrum virginicum	Culver's root
Selaginellaceae	*Selaginella rupestris*	northern selaginella
Smilacaceae	*Smilax herbacea*	smooth carrionflower
	Smilax lasioneura	Blue Ridge carrionflower
Solanaceae	*Physalis heterophylla*	clammy groundcherry
	Physalis virginiana	Virginia groundcherry
Ulmaceae	*Celtis occidentalis*	common hackberry
	Ulmus americana	American elm
	Ulmus pumila	Siberian elm
Urticaceae	*Parietaria pensylvanica*	Pennsylvania pellitory
	Urtica dioica	stinging nettle
Verbenaceae	*Verbena stricta*	hoary verbena
Violaceae	*Viola nephrophylla*	northern bog violet
Vitaceae	*Parthenocissus vitacea*	woodbine
	Vitis riparia	riverbank grape

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 372/124454, April 2014

National Park Service
U.S. Department of the Interior

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

www.nature.nps.gov