



Wind Cave National Park Plant Community Composition and Structure Monitoring

2011 Annual Report

Natural Resource Technical Report NPS/NGPN/NRTR—2012/534



ON THE COVER

A view of a Wind Cave National Park, 2011
Photograph by: Ryan Manuel, NGPN, NPS

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Executive Summary

The Northern Great Plains Inventory & Monitoring Network (NGPN) was established to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of ecosystems in thirteen parks located in 5 northern Great Plains states. NGPN identified upland plant communities, exotic plant early detection, and riparian lowland communities as vital signs that can be used to better understand the condition of terrestrial park ecosystems. Upland and riparian ecosystems are important targets for vegetation monitoring because the status and trends in plant communities provide critical insights into the status and trends of other biotic components within those ecosystems.

In 2011, NGPN began plant community monitoring in Wind Cave National Park (WICA). We sampled vegetation at 13 long-term monitoring plots between July 5-21st and on September 7th and recorded a total of 258 vascular plant species. We visited an additional 14 plots to establish them for future monitoring. This effort was the first year in a multiple-year venture to understand the status of upland plant communities in WICA. At the end of 5 years, there will be an in-depth report describing the status of the plant communities. In this report, we provide a simple summary of our results from sampling in 2011. We found the following:

- Absolute vascular plant cover was high due to a wet spring and grasses and sedges made up the bulk of vascular plant cover at all sites.
- The sites at WICA had a large diversity of vascular plants. Average native species richness in the 10 m² quadrats was 21 ± 3.2 species (mean $\pm$ standard deviation).
- Ponderosa pine was the most common component of the 8 forest plots in WICA. Few of the live ponderosa pine trees we surveyed in 2011 showed signs of insects or decay.
- We identified 2 rare plants in our plots at WICA: buff fleabane (*Erigeron ochroleucus*) and nylon hedgehog cactus (*Echinocereus viridiflorus*).
- The number of exotic species was relatively low in all sites, with a relative cover of 13% across the plots. Japanese brome, the most ubiquitous exotic target species, was found at 16 of the 27 sites visited in 2011, but in low abundance.

Acknowledgments

We thank all the authors of the NGPN Plant Community Monitoring Protocol, particularly Amy Symstad for outstanding guidance on data collection and reporting. We thank the Northern Great Plains Fire Management team for ongoing assistance with fieldwork and development of methods. We greatly appreciate the staff at WICA, particularly Beth Burkhart, for providing logistical support. The 2011 NGPN vegetation field crew of Isabel Ashton, Kara Paintner-Green, Michael Bynum, Michael Prowatzke, Timothy Pine, Lauren Baur, Belinda Lo, Ryan Manuel, Lee Margadant, and Daina Jackson collected and entered the data included in this report. We thank Amy Symstad, Beth Burkhart, Kevin Kovacs, and WICA seasonals for helping us with data collection in the field. We thank Timothy Shepherd for invaluable support and instruction on managing data in the FFI database and Stephen Wilson for assistance with the GIS data. We thank Beth Burkhart for providing comments on a draft of this report.

One of the objectives of the National Park Service (NPS) Inventory & Monitoring (I&M) Program is to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. The Northern Great Plains I&M Network (NGPN) includes thirteen parks located in 5 northern Great Plains states across 6 ecoregions (Figure 1) and vary widely in size, amount of visitor use, and management context.

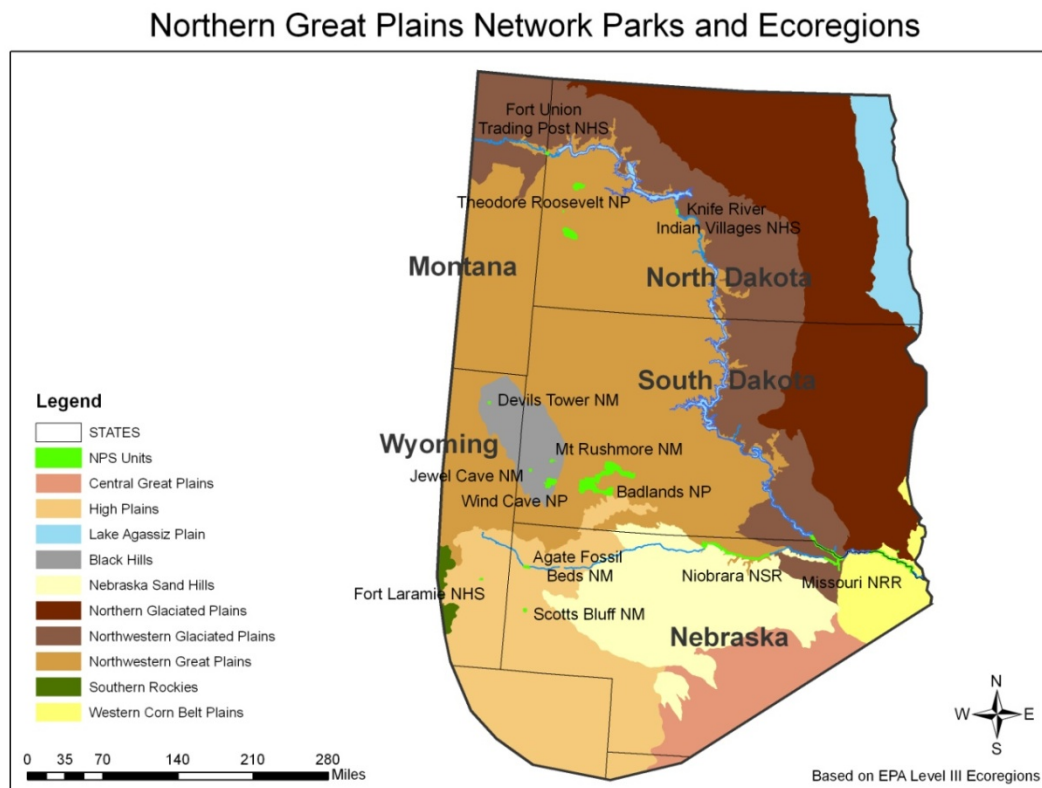


Figure 1. Parks and ecoregions of the Northern Great Plains Network. Based on the U.S. Environmental Protection Agency's Level III ecoregions classes (Omernik 2007).

NGPN identified upland plant communities, exotic plant early detection, and riparian lowland communities as vital signs that can be used to better understand the condition of terrestrial park ecosystems (Gitzen et al. 2010). Network-wide land cover is dominated by native upland grassland, but some small parks are dominated by old fields and recent prairie plantings (Symstad et al. 2011). Other major land cover types include barren or sparsely vegetated areas (Badlands and Theodore Roosevelt National Parks) and ponderosa pine forests and woodlands in Black Hills parks. Riparian hardwood forests comprise a small portion of the area but have disproportionately large ecological significance because of their value to wildlife species.

The NGPN selected upland and riparian ecosystems as an important vegetation monitoring target because knowing the status and trends in plant communities of any terrestrial ecosystem is critical to understanding the status and trends in most other biotic components of that ecosystem. Not only are plants the source of food for other organisms, but they also provide organisms cover from predators and the elements, structure for basic life-history processes (e.g., nest sites), and substrate on which to grow. Plant communities influence local, regional, and global climate through evapotranspiration, albedo, and greenhouse gas emissions and absorption (Smith et al. 1997). Fire regimes (D'Antonio and Vitousek 1992) and flood behavior (Anderson et al. 2006) are in part mediated by the species that comprise plant communities and the structure that they create. Plants are the major source of organic inputs into soil and aquatic systems. Finally, vegetation is a large part of the scenery that visitors to NPS units come to enjoy.

The long-term objectives of our plant community monitoring effort (Symstad et al. 2011) in WICA are to:

1. Determine park-wide status and long-term trends in vegetation species composition (e.g., non-native vs. native, forb vs. graminoid vs. shrub) and structure (e.g., cover, height) of herbaceous and shrub species.
2. Determine park-wide status (at 5-year intervals) and long-term trends of tree density by species, height class, and diameter class, and of fuel loads.
3. Improve our understanding of the effects of external drivers and management actions on plant community species composition and structure by correlating changes in vegetation composition and structure with changes in climate, landscape patterns, atmospheric chemical composition, fire, and invasive plant treatment.

This report is intended to provide a timely release of basic data sets and data summaries for our initial sampling efforts in 2011 at WICA. We collected data from 13 plots in a rotating panel design and it will take 4 more years to collect data from every plot in the park. We expect to produce reports with more in-depth data analysis and interpretation when we complete 5 years of sampling (i.e., visit and sample every plot in the park twice, following a rotating panel design that stipulates 2 years of visitation and 3 years of rest per 5-year period). In 2012, we will conduct a large effort to examine forest structure and health in WICA. Reports, spatial data, and data summaries can also be provided as needed for park management and interpretation.

Methods

The NGPN Plant Community Composition and Structure Monitoring Protocol (Symstad et al. 2011) describes in detail the methods used for sampling upland and riparian vegetation in 11 parks of the network. Below, we briefly describe the general approach, sample frame, plot locations, and sampling methods. For those interested in more detail, please see Symstad et al. 2011, available at <http://science.nature.nps.gov/im/units/ngpn/monitor/plants/plants.cfm>

Sample design

NGPN has implemented a survey to monitor vegetation in WICA using a Generalized Random Tessellation Stratified (GRTS) sampling design (Stevens and Olsen 2003, 2004). Probability-based surveys provide unbiased estimation of both status and, with repeated visits, trend across a resource (Larsen et al. 1995). When implemented successfully, probability-based survey designs allow for unbiased inference from sampled sites to un-sampled elements of the resource of interest (Hansen et al. 1983). The goal of our probability-based design is to determine the *status* of vegetation after 5 years and from then on, the *trend* in vegetation.

The methods for the development of the survey design and site selection are described in detail in Symstad et al. 2011. In brief, a probability-based survey design consists of implementing the following steps prior to field sampling: defining a resource or target population and any subpopulations of interest, creating a sample frame within the target population, selecting sites to visit within the sample frame, and determining when to sample. For WICA, we define the target population as vegetation in the entire park and the sample frame as the entire park. The management importance of riparian areas in WICA is disproportionate to area. In the future, plots may be added to incorporate riparian areas, but these would not be included in this GRTS design. For all parks, we exclude the following areas from the sample frame: administrative areas, roads, canals, or utility lines and an appropriate buffer, areas within 10 m of a park boundary, paved trails, areas with little to no potential for terrestrial vegetation (e.g. large areas of bare rock), areas that are dangerous or prohibitively difficult to access or work on, and areas that are not owned by the park. In WICA, we also excluded a small, isolated parcel owned for water supply purposes. The final design includes 35 randomly located upland sites representing the park where vegetation will be sampled close to peak phenology (early July) (Figure 2).

An ideal revisit design would consist of a large number of sites distributed throughout a park being sampled every year. Limited resources, as well as the danger of plot wear-out (trampling and other effects of sampling), precluded this design. Instead, NGPN intensive plant community composition and structure monitoring uses a connected [2-x] rotating-panel design: every park is visited every year, but sites are grouped into panels where each panel (and the plots therein) is measured for 2 consecutive years followed by 3 or more years without sampling. Because only a subset of panels (and therefore plots) are visited each year, this allows more sites than can be visited in 1 year to be included in the sample design, while including revisitation of sites to address annual variability. Compared to the always-revisit design, connected panel designs, in which each panel is revisited periodically, sacrifice little power for detecting trend (Urquhart and Kincaid 1999) but provide much greater spatial coverage, and thus improved precision in estimates of status. At WICA, we will visit 2 panels, each with 7 sites, every year and after 5 years we will have visited all sites twice (Figure 3). In 2011, we visited sites in panel 1 and panel 5 (Figure 2).



Northern Great Plains Inventory and Monitoring Network Plant Community Monitoring

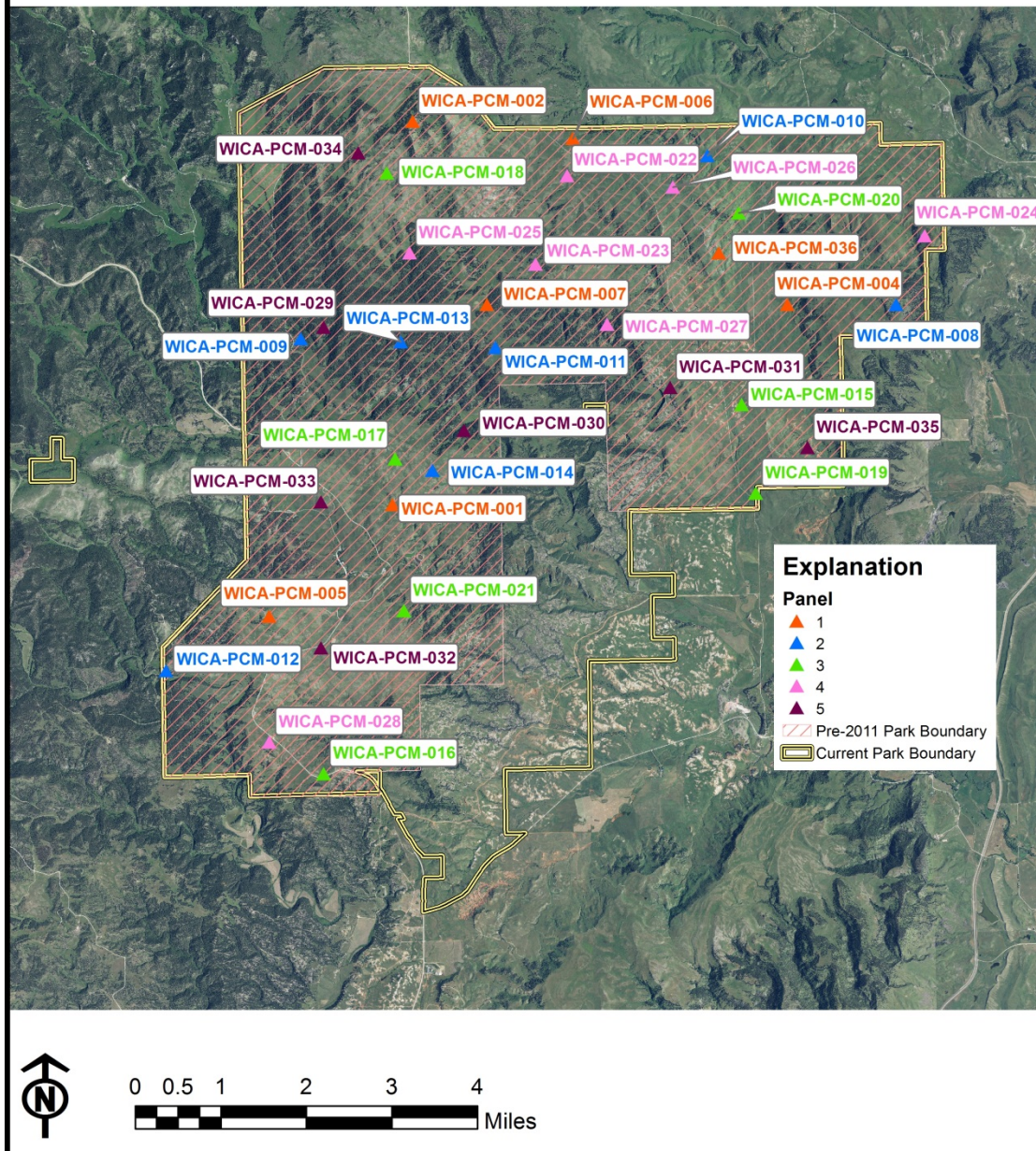


Figure 2. Map of WICA and plant community monitoring plots. Plots in Panel 1 (orange) and Panel 5 (purple) were visited in 2011.

Year↓ / Panel→	P1	P2	P3	P4	P5
2011	7*				7
2012	7	7			
2013		7	7		
2014			7	7	
2015				7	7
2016	7				7
2017	7	7			
2018		7	7		
2019			7	7	
2020				7	7
2021	7				7

*There are 7 plots in each panel.

Figure 3. [2-3] revisit design for intensive plant community composition and structure monitoring at most NGPN parks. Five panels are used in the park. Data are collected in all the plots of a given panel, 2 of every 5 years. Blank cells indicate no plots in the panel are visited that year; at WICA there are 7 plots in a panel. Thus, 14 plots (2 panels) are sampled each year and the total sample size is 35.

The number of plots allocated to each park and to strata within parks is influenced by a combination of factors, including field work logistics, statistical power estimations (see Symstad et al. 2011), and conformity to the desired revisit design. Plot numbers across parks are allocated roughly proportional to the size of the sample frame for that park, although the minimum number of plots per park was set at 15. At WICA, there are currently 35 monitoring plots. An additional 80 forested plots will be monitored on a separate 5 year schedule starting in 2012.

Plot layout and sampling

The primary sample unit for intensive plant community composition and structure monitoring in the NGPN consists of a rectangular, 50 m x 20 m (0.1 ha), permanent plot (Figure 4). These are hereafter referred to as “intensive plots”. In 2011, sampling at WICA took a 5 to 6 person crew approximately 82 hours with travel time (see Appendix A for a detail of activities each day). We were scheduled to sample vegetation at 14 plots, but we were able to sample herbaceous vegetation at only 12 plots due to lack of time. We were able to sample forest structure and fuels in 1 of the 2 plots where herbaceous sampling was missed. We visited an additional 14 plots in the fall to establish them for future monitoring. Below, we briefly describe the methods we used for marking and sampling the plots.

Establishing, Marking, and Photographing Long-term Monitoring Plots

Locations of all intensive plots are determined before monitoring begins in the site evaluation process. At this time, a single plot marker, marked with a metal tag identifying the plot and the marker as the center (C), is driven into the ground at the center of the plot (Figure 5). At plot establishment (which may be done prior to the first visit for data collection), 2 permanent transects are marked by driving rebar markers into the ground at the end points of each transect. A metal tag imprinted with the park code, plot ID, corner name (A0, A50, B0, or B50), and establishment date is attached to each marker. Each transect is also marked with large nails and

washers sunk flush with the ground at 10.92 m, 23.42 m, 35.92 m, and 46.84 m from the 0 end of each transect. Figure 6 is a photographic sample of the tags and washers used by NGPN.

At each transect end, a photograph is taken down the length of the transect. When trees and/or tall shrub species are present in or near the plot, the ends of 2 additional perpendicular, 100-ft (30.48 m) transects centered at the C plot marker are marked with large nails and washers (Figure 4). One of these transects (T1) is parallel to the herb-layer transects and the second (T2) is perpendicular to that transect.

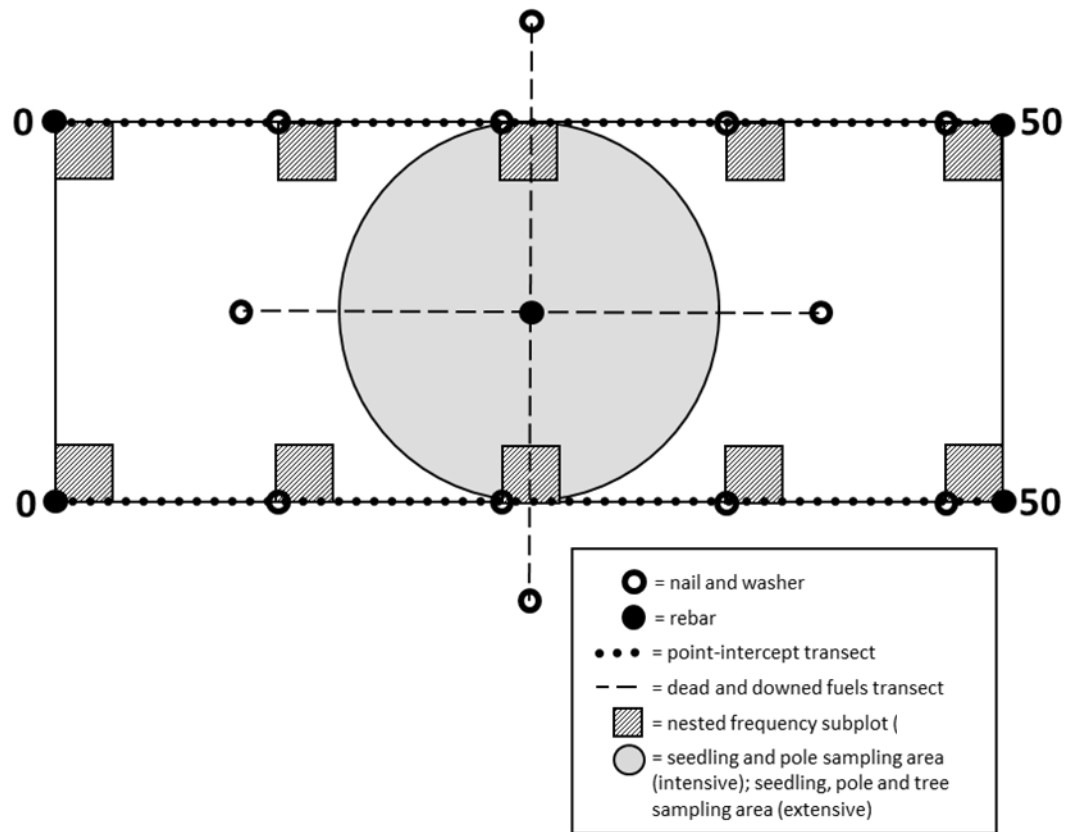


Figure 4. Layout for NGPN intensive plant community composition and structure plots.



Figure 5. A sample of the center marker at an NGPN long-term vegetation monitoring plot. The rebar is bent in the field with a brass tag noting the plot number, date of installation, and location. A compass is used for scale.



Figure 6. A sample of tags and washers used to mark long-term vegetation monitoring plots in the NGPN. From the top left and working clockwise: a center tag from PCM-08 in SCBL evaluated on May 5, 2009; a tag used to mark the end of the A transect at WICA PCM-01; a tag used to mark the center of an extensive plot in MORU; and a washer used to mark the beginning of the second tree transect. In all cases, the tags are close or flush to the ground. The brass tags are fixed to rebar with wire, and the washer is held in place by a large nail.

Plant Sampling

Data on ground cover and herb-layer (≤ 2 m height) height and foliar cover were collected on 2 50 m transects (the long sides of the plot) using a point-intercept method at each plot. Starting at the 0 end of each transect, a 50 m tape was stretched over the length of the transect, ensuring that it followed the path marked by the nails and washers (Figure 4). At 100 locations along the transects (every 0.5 m) a pole was dropped to the ground and all species that touched the pole were recorded, along with ground cover, and the height of the canopy (Figure 7).

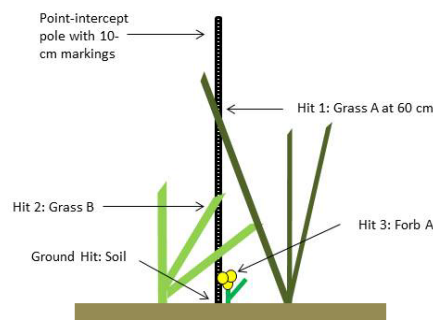


Figure 7. The NGPN point-intercept method captures multiple layers of the plant canopy.

Species richness data from this point-intercept method are supplemented with species presence data collected in 5 sets of nested square quadrats (0.01 m^2 , 0.1 m^2 , 1 m^2 , and 10 m^2 ; Figure 8) located systematically along each transect. Nested quadrats are located so that they occur inside the $20\text{ m} \times 50\text{ m}$ plot (Figure 4). Beginning with the 0.01 m^2 quadrat, all species rooted in the quadrat are identified and recorded. Once all species in this quadrat are recorded, the observer moves onto the 0.1 m^2 quadrat, listing only species not observed in the 0.01 m^2 quadrat. This is repeated in the 1.0 m^2 and 10 m^2 quadrats. Only species rooted in a quadrat are included in the species list for that quadrat.

Unknown species were recorded in the field using a unique identifier and collected or photographed. Most of these unknowns were subsequently identified by M. Bynum. However, in some cases the plant was too small or difficult to identify. In these cases, the species was classified by growth form and, where possible, lifecycle (e.g., annual graminoid).

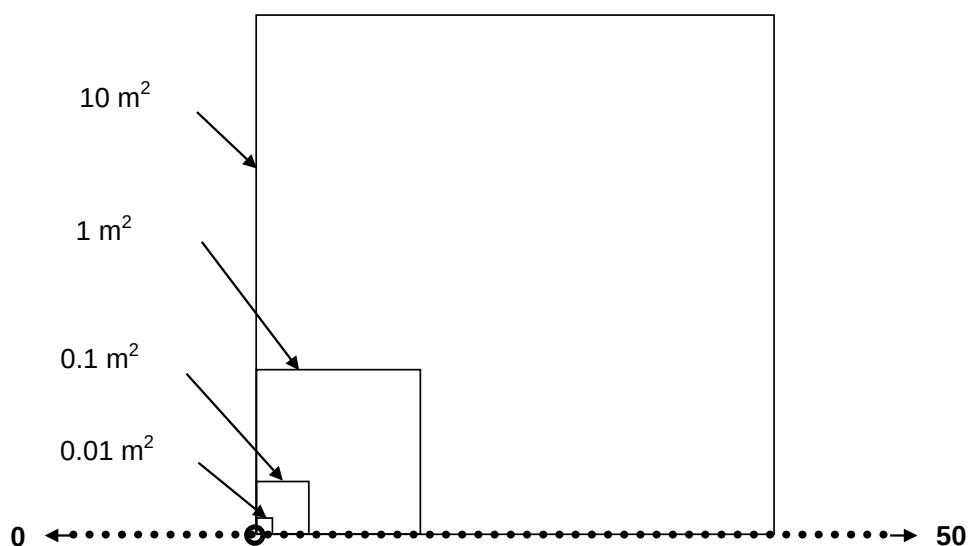


Figure 8. Arrangement of nested quadrats along tape used for point-intercept sampling. Open circle indicates permanent marker (nail and washer or, at 0 end of transect, rebar).

Where applicable, tree regeneration and tall shrub density data are collected within a 10 m-radius, circular subplot centered at the center of the $50\text{ m} \times 20\text{ m}$ plot. In this subplot or a subset thereof, tree and targeted tall shrub seedlings are tallied by species and size class. Size classes are defined as follows. A tree has a diameter at breast height (DBH) of greater than 15 cm. A pole has a DBH of $> 2.54\text{ cm}$ but $< 15\text{ cm}$. A sapling has a DBH $< 2.54\text{ cm}$ but is $>$ than 1.37 cm tall. A seedling is $< 1.37\text{ cm}$ tall. DBH, status (live or dead), and species are recorded for all poles and trees and targeted tall shrubs.

Trees with DBH $> 15\text{ cm}$, within the entire 0.1 ha plot, are mapped and tagged, and species, DBH, status, and condition (e.g., leaf-discoloration, insect-damaged, etc.) are recorded for each tree. Where appropriate (i.e., in ponderosa pine forest or woodland in Black Hills parks), dead and downed woody fuel load data are collected on 2 perpendicular, 100 ft (30.49 m) transects centered at the center of the plot.

At all plots, we also surveyed the area for common disturbances and target species of interest. Common disturbances included such things as roads, rodent mounds, animal trails, and fire. For all plots the type and severity of the disturbances were recorded. The target species lists were developed in cooperation with the park and NGPN staff during the winter/spring prior to the field season. Usually these are invasive and/or exotic species that are not currently widespread in the park but pose a significant threat if allowed to establish. For each target species that was present at a site, an abundance class was given on a scale from 1-5 where 1 = one individual, 2 = few individuals, 3 = cover 1-5% of site, 4 = cover 5-25% of site, and 5 = cover > 25% of site. The information gathered from this procedure is critical for early detection and rapid response to such threats. In addition, this method tracks the presence of plant species that are considered rare or vulnerable to loss in South Dakota, and may occur in WICA. These species are also tracked by the South Dakota Natural Heritage Program (<http://gfp.sd.gov/wildlife/threatened-endangered/rare-plant.aspx>). The WICA target species list for 2011 can be found in Table 1

Table 1. Target species in WICA for the 2011 field season.

Invasives/noxious weeds/exotics		
Species Code	Scientific Name	Common Name
ACRE3	<i>Acroptilon repens</i>	Russian knapweed/ hardheads
BRJA	<i>Bromus japonicus</i>	Japanese brome/ field brome
BRTE	<i>Bromus tectorum</i>	Cheatgrass
CANU4	<i>Carduus nutans</i>	nodding plumeless thistle/ musk thistle
CESTM	<i>Centaurea biebersteinii</i>	spotted knapweed
CIAR4	<i>Cirsium arvense</i>	Canada thistle
CIVU	<i>Cirsium vulgare</i>	bull thistle
CYOF	<i>Cynoglossum officinale</i>	houndstongue/ gypsyflower
EUES	<i>Euphorbia esula</i>	leafy spurge
HYN1	<i>Hyoscyamus niger</i>	black henbane
HYPE	<i>Hypericum perforatum</i>	common St. Johnswort
LEVU	<i>Leucanthemum vulgare</i>	oxeye daisy
LIDA	<i>Linaria dalmatica</i>	Dalmatian toadflax
LIVU2	<i>Linaria vulgaris</i>	yellow toadflax
MEOF	<i>Melilotus officinalis</i>	yellow clover
ONAC	<i>Onopordum acanthium</i>	Scotch thistle
PORE5	<i>Potentilla recta</i>	sulphur cinquefoil
SATR12	<i>Salsola tragus</i>	prickly Russian thistle
TAVU	<i>Tanacetum vulgare</i>	common tansy
VETH	<i>Verbascum thapsus</i> L.	common mullein
At risk/rare		
Species Code	Scientific Name	Common Name
ACRO7	<i>Achnatherum robustum</i> ³	sleepygrass
BOCA5	<i>Botrychium campestre</i> ²	prairie moonwort/ Iowa moonwort
BOL17	<i>Botrychium lineare</i> ¹	slender moonwort/ narrowleaf grapefern
CLHI	<i>Clematis hirsutissima</i> ²	sugarbowl/ hairy clematis
CRCA8	<i>Cryptantha cana</i> ²	silver-mounded candleflower /mountain cryptantha
CYPA19	<i>Cypripedium parviflorum</i> ³	lesser yellow lady's slipper
ECV12	<i>Echinocereus viridiflorus</i> ³	nylon hedgehog cactus
ELDI3	<i>Elymus diversiglumis</i> ⁵	interrupted wildrye/ diverseglume wildrye
ERAC2	<i>Erigeron acris</i> ⁵	bitter fleabane
EROC	<i>Erigeron ochroleucus</i> ⁴	buff fleabane
ERPAH	<i>Ericameria parryi</i> ⁶	Parry's rabbitbrush
IPSP	<i>Ipomopsis spicata</i> ⁴	spiked ipomopsis / spike gilia
LEARA	<i>Lesquerella arenosa</i> var. <i>argillosa</i> ³	Great Plains bladderpod/ secund bladderpod
PHAL2	<i>Phleum alpinum</i> ²	alpine timothy
THME	<i>Thelesperma megapotamicum</i> ³	Hopi tea/greenthread
TOEX2	<i>Townsendia exscapa</i> ⁴	Easter daisy/ stemless Townsend daisy
TOHO	<i>Townsendia hookeri</i> ³	Hooker's Easter (Townsend) daisy

¹ S1, Critically imperiled because of extreme rarity; ² S2, Imperiled because of rarity; ³ S3, Either very rare and local throughout its range, or found locally (even abundantly at some of its locations) in a restricted range; ⁴ S4, Apparently secure, though it may be quite rare in parts of its range, especially at the periphery. Cause for long term concern; ⁵ Historically known; ⁶ SU, Possibly in peril, but status uncertain, more information needed.

Data Management and Analysis

After the field work was completed, field sheets were scanned and stored in fire-proof cabinets, and the data were entered by the NGPN seasonal vegetation crew. FFI (FEAT/FIREMON Integrated; <http://frames.gov/ffi/>) is the primary software environment used for managing NGPN plant community data. NGPN uses its components for data entry, data storage, and basic summary reports. FFI is used by a variety of agencies (e.g., NPS, USDA Forest Service, U.S. Fish and Wildlife Service), has a national-level support system, and generally conforms to the Natural Resource Database Template standards established by the Inventory and Monitoring Program.

Species names, codes, and common names are from the USDA Plants Database (USDA-NRCS 2012). However, nomenclature follows the Integrated Taxonomic Information System (ITIS) (<http://www.itis.gov>). In the few cases where ITIS recognizes a new name that was not in the USDA PLANTS database, the new name was used and a unique plant code was assigned.

After data for the sites were entered, the data were verified. This was done by comparing the entered data to the original field data sheets, and detected errors were corrected immediately. To minimize transcription errors, 100% of records were verified to their original source. A further 10% of records were reviewed a second time by I. Ashton or M. Prowatzke. When errors were found in the reviews, the entire data set was verified again. After all data were entered and verified, automated queries were developed to check for errors in the data. For instance, a query was developed that noted all plots where a species appeared twice within 1 nested quadrat. When errors were caught by the crew or the automated queries, changes were made to the original datasheets and the FFI database.

For analysis of data from intensive plots, the plot is used as the unit of replication and quadrats or transects are pooled or averaged. Data from each plot are summarized for a variety of variables including: relative cover of growth forms (shrubs, grasses, forbs), absolute cover of bare soil, total herb-layer foliar cover, density and basal area of trees, species richness and diversity, relative abundance of functional groups, and proportions of foliar cover and species richness that are non-native. Growth forms were based on definitions from the USDA Plants Database (USDA-NRCS 2012). Warm-season grasses were identified primarily using a guide by Skinner (2010). Summaries were done using FFI reports and statistical summaries were done using R software (version 2.11.0).

Results

In the 13 plots we visited in WICA during 2011, we recorded 258 vascular plant species (Appendix B). We found an additional 13 plants that could be identified only to genera. The most common families were Asteraceae and Poaceae.

Absolute percent and relative cover

From the point-intercept data, we found 12 plots to average 173 ± 49.3 % (mean $\pm$ standard deviation) total herb layer cover and 26 ± 24.2 % bare ground. The absolute canopy cover can be greater than 100% because we record multiple layers of plants and it was a fairly wet year with abundant growth.

Graminoids, which includes grasses, sedges, and rushes, had an average cover of 137 ± 47.7 %. This was much higher than other plant life-forms (Figure 9). Plant composition varied among the plots and there were no species that were found at all 12 plots. The most common species were mostly graminoids: western wheatgrass (*Pascopyrum smithii*; 42 ± 26.1 % absolute cover) and sun sedge (*Carex inops* ssp. *heliophila*; 4 ± 3.6 %) were found at 11 plots. Blue grama (*Bouteloua gracilis*; 7 ± 5.8 %), threadleaf sedge (*Carex filifolia*; 9 ± 9.6 %) and Kentucky bluegrass (*Poa pratensis*) were recorded in 10 plots. The most common forb was slimflower scurfpea (*Psoralidium tenuiflorum*; 6 ± 4.6) found at 10 sites.

Of the 12 plots at WICA, the average relative percent cover of exotic species was 13 ± 11.4 %. We found the average relative percent cover of warm season graminoids to be 32 ± 19.3 %.

Species richness, diversity, and evenness

We measured diversity at the plots in 2 ways: the Shannon Index and Pielou's Index of Evenness. The Shannon Index, H' , is a measure of the number of species in an area and how even abundances are across the community. It typically ranges between 0 (low richness and evenness) to 3.5 (high species richness and evenness). Pielou's Index of Evenness, J' , measures another aspect of diversity-- how even abundances are across taxa. It ranges between 0 and 1, where higher numbers indicate that a community is not even or that just a few species make up the majority of the total cover. From the point-transect data, we found average plot diversity, H' , to be 2.4 ± 0.39 . Evenness, J' , averaged 0.72 ± 0.08 across the plots. When including only native species, average diversity and evenness were 2.3 ± 0.35 and 0.72 ± 0.08 , respectively. Species richness varies by the scale that it is examined. Table 2 presents average species richness for the point-intercept, 1 m² quadrats, and 10 m² quadrats for the 12 plots in 2011. In general, richness increases in the larger quadrat size. While graminoids have greater absolute cover, forb richness tended to be greater than graminoid richness. On average, there are about 3 exotic species found in each plot along the point-intercept (Table 2).

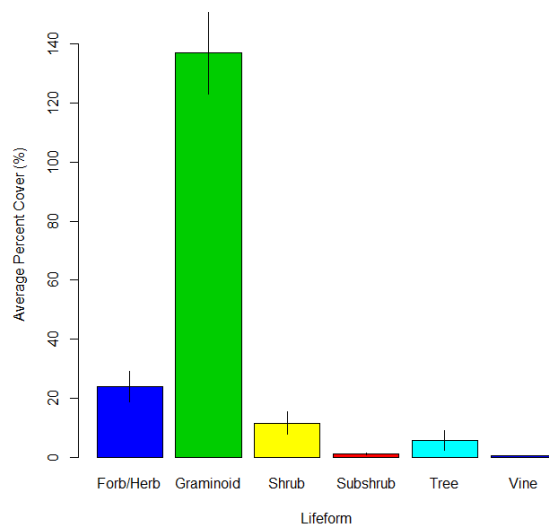


Figure 9. Absolute percent cover of different life-forms in 12 plant community monitoring plots in WICA in 2011. Bars represent means across the 12 plots $\pm$ standard errors. Graminoids were the most abundant plant life-form across all plots at WICA.

Table 2. Average plant species richness at 12 plots at WICA in 2011. Values represent means $\pm$ standard deviation.

	Point-intercept	1 m ² quadrats	10 m ² quadrats
Species richness	29.7 (8.72)	12.7 (2.62)	23.7 (3.78)
Native species richness	26.8 (7.13)	11.5 (2.40)	21.2 (3.20)
Exotic species richness	2.8 (1.95)	1.6 (0.53)	2.7 (1.25)
Graminoid species richness	13.1 (3.92)	4.9 (1.57)	7.3 (2.33)
Forb species richness	13.2 (5.81)	6.7 (2.06)	13.9 (3.09)

Forest structure and surface fuels

In 2011, 8 of the 12 plots we visited in WICA had woody species. We measured the density of 3 tree species, Rocky Mountain juniper (*Juniperus scopulorum*), ponderosa pine (*Pinus ponderosa*), and American elm (*Ulmus americana*). The density of these species by size class at each plot is given in Table 3.

Forest structure and composition varied considerably among the plots (Table 3). Ponderosa pine trees or seedlings were present at 7 of the 8 sites. Juniper and American elm were each found in only 1 plot, while ponderosa pines were recorded in 7 of the 8 forested plots. Of the 127 ponderosa trees were measured, we found evidence of dieback from insects or disease in only 3.

Table 3. Tree density at 8 forested plots at WICA in 2011.

Size Class	Juniper (1 plot; stems hectare ⁻¹)	Ponderosa Pine (7 plots; stems hectare ⁻¹)	American Elm (1 plot; stems hectare ⁻¹)	Snag (8 plots; stems hectare ⁻¹)
Seedlings	1782	3846	5251	n/a
Saplings	573	623	0	n/a
Poles	382	364	0	191
Trees	120	160	0	18
Total stems	2857	4992	5251	209

Surface fuels were measured in 5 plots with ponderosa pine litter layers including: PCM-002, PCM-007, PCM-029, PCM-030, and PCM-034. There was considerable variation in fuel loads across the 5 plots. Average fuel loads for fine (1-100-hour) fuels, coarse (1000-hour) fuels, and sum of litter and duff fuels were 0.9 ± 0.72 , 4.1 ± 5.73 , and 8.0 ± 5.75 tons per acre, respectively. The average total fuel load was 12.9 ± 11.02 tons per acre.

Target species assessments and disturbance

We recorded disturbance and rare and exotic target species occurrence at 27 plots in WICA in 2011. Thirteen plots were from Panel 1 and 5 and described above. The additional 14 plots are from other panels but were visited as part of an effort to establish long-term monitoring plots prior to reading vegetation.

We identified 2 rare target species in our plots in 2011: nylon hedgehog cactus (*Echinocereus viridiflorus*) and buff fleabane (*Erigeron ochroleucus*; Figure 10) in plots PCM_029 and PCM_036, respectively.



Figure 10. Buff fleabane, a rare plant found in WICA in 2011 during plant community monitoring.

Seven exotic target species appeared in the plots we visited in 2011 (Table 4): Japanese brome (*Bromus japonicus*), cheatgrass (*Bromus tectorum*), Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), houndstongue (*Cynoglossum officinale*), yellow sweet clover (*Melilotus officinalis*) and mullein (*Verbascum thapsus*). At least 1 target species was found in 21 of the 27 plots and Japanese brome was the most commonly found.

Of the 27 sites at WICA, 6 showed no evidence of natural or anthropogenic disturbance (Table 4). These were not the same 6 plots where no exotic target species were found. The most common disturbance to sites was from large animal trails and grazing. Prairie dogs were also common disturbance agents (5 plots), but in only 1 case did the entire site overlap with a prairie dog town. Most disturbances recorded were natural disturbances and not from roads, vehicle traffic, or other anthropogenic disturbances.

Table 4. Cover class of target species at 27 plots at WICA in 2011. 1 = one individual, 2 = few individuals, 3 = cover 1-5% of site, 4 = cover 5-25% of site, 5 = cover > 25% of site, present = present at site but cover was not assessed. The shading indicates sites where no target species were found. Asterisks indicate sites with no evidence of disturbance.

Site	Japanese brome	Cheatgrass	Bull thistle	Canada thistle	Houndstongue	Yellow sweet clover	Mullein
WICA_PCM_001	2	-	-	-	-	-	-
WICA_PCM_002	3	2	-	1	present	-	2
WICA_PCM_004	present	2	-	-	-	-	-
WICA_PCM_005	2	-	-	-	present	present	-
WICA_PCM_006	present	-	-	-	-	-	-
WICA_PCM_007	-	-	-	-	2	-	-
WICA_PCM_015	-	-	-	-	-	-	-
WICA_PCM_016	-	-	-	2	-	-	2
WICA_PCM_017	-	-	-	-	-	-	-
WICA_PCM_018	2	2	-	-	1	-	2
WICA_PCM_019	-	-	-	-	-	-	-
WICA_PCM_020*	-	-	-	-	-	-	-
WICA_PCM_021	5	-	-	-	-	-	-
WICA_PCM_022*	3	-	-	-	-	1	2
WICA_PCM_023	-	-	-	-	2	-	2
WICA_PCM_024*	-	-	-	-	-	-	-
WICA_PCM_025	-	-	-	2	-	-	2
WICA_PCM_026	-	-	-	-	-	-	-
WICA_PCM_027*	2	-	-	-	-	-	-
WICA_PCM_028*	2	-	-	-	-	-	-
WICA_PCM_029	present	-	present	1	-	1	present
WICA_PCM_030	-	-	-	-	2	present	1
WICA_PCM_032	present	2	-	present	-	present	present
WICA_PCM_033	present	3	-	-	2	2	2
WICA_PCM_034	2	-	-	-	1	-	-
WICA_PCM_035*	present	-	-	-	-	2	-
WICA_PCM_036	2	2	-	-	-	present	-

Discussion

The goal of our plant community monitoring efforts in WICA is to determine the status and trend in vegetation composition and structure and to understand how natural and anthropogenic disturbance and management decisions influence vegetation. As of 2011, we have completed the first year of field work; while we have increased our understanding of vegetation composition and structure, we cannot yet describe park-wide status or trends. Below, we summarize the results from above and highlight some of the most interesting aspects of the plant community monitoring.

There was considerable variation among plots, but on average absolute vascular plant cover was 173 %; productivity was high due to a wet spring. The sites at WICA had a notably large diversity of vascular plants. Average native species richness in the 10 m² quadrats was 21.2 species (Table 2). We found an average of 2.7 exotic plants in every 10 m² quadrat. Graminoids, which includes all grasses, sedges, and rushes, made up the bulk of cover at all sites (Figure 9). Forbs, or broad-leaved herbaceous plants, were less abundant but more diverse than graminoids. Shrubs, vines, and subshrubs were not a large component of the cover at the sites we visited (Figure 9).

Graminoids can be further classified by their photosynthetic pathway. Warm season graminoids have a photosynthetic pathway (C4) that particularly adapts them to hot climates and an atmosphere low in carbon dioxide. These warm season graminoids grow primarily during the hot summer months and tend to be very drought tolerant. Cool season graminoids are C3 plants that tend to grow best in cooler temperatures. For example, junegrass (*Koeleria macrantha*) is a cool season grass and blue grama (*Bouteloua gracilis*) is a warm season grass. From the average across these 12 sites, 32% of the relative cover was made up of warm-season grasses. Examining the trend over time in warm-season graminoid cover and climate trends may elucidate whether warm-season grasses are increasing in abundance due to warmer and drier conditions.

Forest structure and composition varied considerably among the plots (Table 3). Not surprisingly, ponderosa pine was the most common tree species across the plots. There was little evidence of disease, decay, or insects in the live trees we measured. Downed and dead total fuel loads in the 5 forested sites averaged 12.9 ± 11.02 tons per acre.

While the sites had fairly few exotic species, their cover was disproportionately high. Relative cover of exotics species averaged 13% across the plots. In the 27 plots we visited for plant sampling and plot establishment, target exotic species were found in 21 (Table 4). Japanese brome was the most ubiquitous, occurring at 16 sites. There did not appear to be a correlation between target species presence and disturbance.

Results from our vegetation monitoring can be summarized in a “connect-the-dots” or a resource condition summary table (Table 5). These tables can be used to describe the status and trend in vital signs or other indicators of ecosystem health. We chose a handful of the key metrics representing 2 vital signs, which we will continue to monitor over time at WICA. The current value is based on sampling in 2011 and the level of inference is simply the number of sites where we sampled that attribute. After 1 complete rotation in the WICA sampling design (5 years), a current value will represent a 5-year mean and the level of inference will be park-wide. At such

time, we will also be able to estimate baseline reference values and begin to estimate trends in these key metrics. Over time, the vegetation data collected at these sites will greatly add to our understanding and documentation of change in the upland plant communities at WICA.

Table 5. Natural resource condition summary table for plant communities in WICA.

Vital Sign	Metric	Current Value (mean $\pm$ SD)	Level of inference	Reference Value	Rationale
Exotic Plant Early Detection	% of sites where target species were encountered	78%	27 sites	TBD	Early detection of exotic species
	Number of sites where cheatgrass > 5%	0	27 sites	TBD	Effectiveness of exotic species management
Upland Plant Communities	Mean absolute herb-layer cover	173 $\pm$ 49.3 %	12 sites	TBD	Forage availability, climatic trends, erosion potential, habitat for small mammals and birds
	Ground-layer bare soil cover	26 $\pm$ 24.2 %	12 sites	TBD	
	Mean relative percent cover of exotic species	13 $\pm$ 11.4 %	12 sites	TBD	Effectiveness of exotic species management
	Percent of graminoid cover that is warm season	32 $\pm$ 19.3 %	12 sites	TBD	Climatic trends
	Mean native species richness in 10 m ² quadrats	21.2 $\pm$ 3.20 species	12 sites	TBD	Diversity maintenance
Fire and Fuel Dynamics	Total fuel load	12.9 $\pm$ 11.02 tons per acre	5 sites	TBD	Potential fire behavior, effectiveness of fire management program

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Appendix A: Field journal for plant community monitoring in WICA for the 2011 season

Plant community composition monitoring in WICA was completed using a crew of 4 to 6 people working 8 10-hour days with approximately 2 hours of overtime. We worked 7 days in July, but were only able to complete 12 of 14 monitoring plots. In September, we visited 1 of the missing plots to sample forest attributes. All work was done as day trips from NGPN offices. In addition to the days described below, the NGPN field crew visited the park on 9/21, 10/4, and 10/13 to establish 14 plots for future monitoring. The crew drove 3 vehicles at various times during the summer and the total mileage for all the trips was 1931 miles. We spent a total of 590 crew hours in WICA in 2011 and 168 hours of other USGS/NPS staff time.

Date	Day of week	Approximate Travel Time (hrs)	Housing	Sites Completed	Notes
Jul 5, 2011	Tuesday	2.5	N/A	PCM_029	
Jul 6, 2011	Wednesday	2.5	N/A	PCM_004 PCM_035	
Jul 7, 2011	Thursday	2.5	N/A	PCM_006 PCM_032	
Jul 18, 2011	Monday	2.5	N/A	PCM_033	
Jul 19, 2011	Tuesday	2.5	N/A	PCM_001 PCM_005	
Jul 20, 2011	Wednesday	2.5	N/A	PCM_002 PCM_034	
Jul 21, 2011	Thursday	2.5	N/A	PCM_030 PCM_036	
Sep 7, 2011	Wednesday	2.5	N/A	PCM_007	Read trees only

Appendix B: List of plant species found in 2011 at WICA

Family	Code	Scientific Name	Common Names
Agavaceae	YUGL	<i>Yucca glauca</i>	beargrass, Great Plains yucca, small soapweed, soapweed yucca, Spanish bayonet, yucca
Anacardiaceae	RHTR	<i>Rhus trilobata</i>	Skunkbush, skunkbush sumac
Anacardiaceae	TORY	<i>Toxicodendron rydbergii</i>	poison ivy, W. Poison ivy, western poison ivy, western poison-ivy
Apocynaceae	APAN2	<i>Apocynum androsaemifolium</i>	bitterroot, flytrap dogbane, spreading dogbane
Asclepiadaceae	ASOV	<i>Asclepias ovalifolia</i>	milkweed, oval-leaf milkweed
	ASPU	<i>Asclepias pumila</i>	low milkweed, plains milkweed
	ASST	<i>Asclepias stenophylla</i>	slimleaf milkweed
	ASVI	<i>Asclepias viridiflora</i>	green antelopehorn milkweed, green comet milkweed, green milkweed
Asteraceae	ACMI2	<i>Achillea millefolium</i>	bloodwort, carpenter's weed, common yarrow, hierba de las cortaduras, milfoil, plumajillo, western yarrow, yarrow (common)
	AGGL	<i>Agoseris glauca</i>	pale agoseris, pale dandelion, pale dandelion, prairie dandelion
	AMPS	<i>Ambrosia psilostachya</i>	Cuman ragweed, perennial ragweed, western ragweed
	ANMI3	<i>Antennaria microphylla</i>	littleleaf pussytoes, Rocky Mountain pussytoes, small leaf everlasting, smallleaf pussytoes
	ANNE	<i>Antennaria neglecta</i>	field pussytoes
	ANPA4	<i>Antennaria parvifolia</i>	smallleaf pussytoes
	ARCA12	<i>Artemisia campestris</i>	common sagewort, field sagewort, Pacific wormwood, wormwood sagewort
	ARFI2	<i>Artemisia filifolia</i>	sand sagebrush, Sand sagebrush, sandhill sage, silvery wormwood
	ARFR4	<i>Artemisia frigida</i>	fringed sagebrush, fringed sagewort, prairie sagewort
	ARLU	<i>Artemisia ludoviciana</i>	cudweed sagewort, gray sagewort, Louisiana sagewort, Louisiana wormwood, mugwort wormwood, prairie sage, white sagebrush
	ARLUL2	<i>Artemisia ludoviciana ssp. ludoviciana</i>	cudweed sagewort, foothill sagewort, Louisiana sagewort, white sagebrush
	BREU	<i>Brickellia eupatorioides</i>	false boneset
	BREUC	<i>Brickellia eupatorioides var. corymbulosa</i>	false boneset
	BREUE	<i>Brickellia eupatorioides var. eupatorioides</i>	false boneset
	CIAR4	<i>Cirsium arvense</i>	Californian thistle, Canada thistle, Canadian thistle, creeping thistle, field thistle
	CIUN	<i>Cirsium undulatum</i>	gray thistle, wavy-leaf thistle, wavyleaf thistle
	CIVU	<i>Cirsium vulgare</i>	bull thistle, common thistle, spear thistle
	COCA5	<i>Conyza canadensis</i>	Canada horseweed, Canadian horseweed, horseweed, horseweed fleabane, mares tail, marestail
	CORA4	<i>Conyza ramosissima</i>	branching conyza, dwarf horseweed
	DYPA	<i>Dyssodia papposa</i>	dogbane dyssodia, dogweed, fetid dogweed, fetid marigold, fetid-marigold, prairie dogweed
	ECAN2	<i>Echinacea angustifolia</i>	Blacksamson, blacksamson echinacea
	ERFL	<i>Erigeron flagellaris</i>	trailing daisy, trailing fleabane
	ERGLG	<i>Erigeron glabellus var.</i>	streamside fleabane

Family	Code	Scientific Name	Common Names
		<i>glabellus</i>	
	EROC	<i>Erigeron ochroleucus</i>	buff fleabane
	ERPU2	<i>Erigeron pumilus</i>	low daisy, low fleabane, shaggy fleabane
	ERSU2	<i>Erigeron subtrinervis</i>	three-nerve fleabane, threenerve fleabane, threeveined fleabane
	GNPA	<i>Gnaphalium palustre</i>	western marsh cudweed
	GRSQ	<i>Grindelia squarrosa</i>	Curleycup gumweed, curlycup gumweed, curlytop gumweed, gumweed, rosinweed, tarweed
	GUSA2	<i>Gutierrezia sarothrae</i>	broom snakeweed, Broomsnakeweed, broomweed, perennial snakeweed, stinkweed, turpentine weed, yellow top
	HEPAP2	<i>Helianthus pauciflorus</i> ssp. <i>pauciflorus</i>	stiff sunflower
	HEVI4	<i>Heterotheca villosa</i>	hairy false goldaster, hairy false goldenaster, hairy goldaster, hairy goldenaster
	LASE	<i>Lactuca serriola</i>	China lettuce, prickly lettuce, wild lettuce
	LIPU	<i>Liatris punctata</i>	dotted blazing star, Dotted gayfeather
	LOAR5	<i>Logfia arvensis</i>	field cottonrose
	LYJU	<i>Lygodesmia juncea</i>	rush skeleton-plant, rush skeletonplant, rush skeletonweed, skeletonplant, skeletonweed
	PACA15	<i>Packera cana</i>	woolly groundsel
	RACO3	<i>Ratibida columnifera</i>	Prairie coneflower, prairie coneflower (upright), prairieconeflower, redspike Mexican hat, upright prairie coneflower
	SOLID	<i>Solidago</i>	goldenrod, goldenrod species
	SOCA6	<i>Solidago canadensis</i>	Canada goldenrod, Canadian goldenrod, common goldenrod
	SOMI2	<i>Solidago missouriensis</i>	Missouri goldenrod, prairie goldenrod
	SOMO	<i>Solidago mollis</i>	ashy goldenrod, soft goldenrod, velvety goldenrod, woolly goldenrod
	SONE	<i>Solidago nemoralis</i>	dyersweed goldenrod, gray goldenrod
	SOPT4	<i>Solidago ptarmicoides</i>	prairie goldenrod, upland white aster, white flat-top goldenrod
	SORIR	<i>Solidago rigida</i> ssp. <i>rigida</i>	stiff goldenrod
	SOSP2	<i>Solidago speciosa</i>	noble goldenrod, showy goldenrod
	SYER	<i>Symphyotrichum ericoides</i>	white heath aster
	SYLA3	<i>Symphyotrichum laeve</i>	smooth blue aster
	SYOB	<i>Symphyotrichum oblongifolium</i>	aromatic aster
	TAOF	<i>Taraxacum officinale</i>	blowball, common dandelion, dandelion, faceclock
	TEAC	<i>Tetranneuris acaulis</i>	stemless actinea, stemless four-nerve daisy, stemless four-nerve-daisy, stemless hymenoxys
	TRDU	<i>Tragopogon dubius</i>	common salsify, goat's beard, goatsbeard, meadow goat's-beard, salsifis majeur, salsify, Western goat's beard, western salsify, wild oysterplant, yellow goat's beard, yellow salsify
	XASP (~ MAPI)*	<i>Xanthisma spinulosum</i>	lacy tansyaster, cut-leaf ironplant, spiny goldenweed
Boraginaceae	CYOF	<i>Cynoglossum officinale</i>	common houndstongue, gypsy-flower, gypsyflower, hound's tongue, houndstongue
	HADE	<i>Hackelia deflexa</i>	nodding stickseed
	LAOCO	<i>Lappula occidentalis</i> var. <i>occidentalis</i>	desert stickseed, flat-spine sheepsburr, flatspine stickseed, western stickseed
	LIIN2	<i>Lithospermum incisum</i>	fringed gromwell, Fringed puccoon, narrowleaf gromwell, narrowleaf pucoon, narrowleaf stoneseed, trumpet stoneseed

Family	Code	Scientific Name	Common Names
	MELA3	<i>Mertensia lanceolata</i>	lanceleaf bluebells, prairie bluebells
Brassicaceae	ALDE	<i>Alyssum desertorum</i>	desert alyssum, desert madwort
	ARAB12	<i>Arabis</i>	rockcress
	ARHI	<i>Arabis hirsuta</i>	hairy rockcress
	ARPY9 (~ARHIP)*	<i>Arabis pycnocarpa</i> var. <i>pycnocarpa</i>	creamflower rockcress, hairy rockcress
	BOHO2	<i>Boechera holboellii</i>	Holboell rockcress, Holboell's rockcress
	BOPI4	<i>Boechera pinetorum</i>	Holboell's rockcress
	CAMI2	<i>Camelina microcarpa</i>	false flax, little-pod false flax, littlepod false flax, littlepod falseflax, littleseed falseflax, small fruited falseflax, smallseed falseflax
	DEPI	<i>Descurainia pinnata</i>	green tansymustard, pinnate tansy mustard, pinnate tansymustard, tansymustard, western tansymustard
	DESO2	<i>Descurainia sophia</i>	flaxweed tansymustard, flixweed, flixweed tansymustard, herb sophia, herb-sophia, pinnate tansymustard, tansymustard
	DRAU	<i>Draba aurea</i>	golden draba, golden whitlowgrass
	DRRE2	<i>Draba reptans</i>	Carolina draba, Carolina whitlow-grass, Carolina whitlowgrass, creeping draba
	ERYSI	<i>Erysimum</i>	wallflower
	ERAS2	<i>Erysimum asperum</i>	western wallflower
	ERCA14	<i>Erysimum capitatum</i>	coast wallflower, sand-dune wallflower, sanddune wallflower, western wallflower
	LEDE	<i>Lepidium densiflorum</i>	common pepperweed, greenflower pepperweed, miner's pepperwort, miners pepperweed, peppergrass, pepperweed, prairie pepperweed
	PHLU6 (~LELU)*	<i>Physaria ludoviciana</i>	foothill bladderpod, Louisiana bladderpod, silver bladderpod
	SIAL2	<i>Sisymbrium altissimum</i>	Jim Hill mustard, tall hedge-mustard, tall mustard, tall tumblemustard, tumble mustard, tumblemustard, tumbleweed mustard
	THAR5	<i>Thlaspi arvense</i>	fanweed, field pennycress, Frenchweed, pennycress, stinkweed
Cactaceae	ECVI2	<i>Echinocereus viridiflorus</i>	green pitaya, nylon hedgehog cactus
	ESCOB	<i>Escobaria</i>	foxtail cactus
	ESMI3	<i>Escobaria missouriensis</i>	Missouri fox-tail cactus, Missouri foxtail cactus
	OPUNT	<i>Opuntia</i>	cactus spp., Prickly pear, prickly pear species, pricklypear, pricklypear and cholla
	OPFR	<i>Opuntia fragilis</i>	brittle cactus, brittle pricklypear, fragile cactus, jumping cactus, little pricklypear, little pricklypear cactus
	OPMA2	<i>Opuntia macrorhiza</i>	grassland pricklypear, plains twistspine pricklypear, twistspine pricklypear
	OPPO	<i>Opuntia polyacantha</i>	plains pricklypear
Campanulaceae	CARO2	<i>Campanula rotundifolia</i>	bluebell, bluebell bellflower, bluebell-of-Scotland, roundleaf harebell
	TRLE3	<i>Triodanis leptocarpa</i>	slimpod Venus' looking-glass, venus lookingglass, venuslookingglass
	TRPE4	<i>Triodanis perfoliata</i>	clasping bellwort, clasping Venus' looking-glass, clasping Venus' lookingglass, clasping venuslookingglass, clasping-leaf venus'-looking-glass, common Venus' lookingglass, roundleaved triodanis, Venus lookingglass
Caprifoliaceae	SYAL	<i>Symphoricarpos albus</i>	common snowberry, snowberry (common)
	SYOC	<i>Symphoricarpos occidentalis</i>	western snowberry, wolfberry
Caryophyllaceae	CEAR4	<i>Cerastium arvense</i>	field chickweed, field mouse-ear chickweed, starry chickweed

Family	Code	Scientific Name	Common Names
	CEFOV2	<i>Cerastium fontanum</i> ssp. <i>vulgare</i>	big chickweed, common mouse-ear chickweed
	PASE	<i>Paronychia sessiliflora</i>	creeping mailwort, creeping nailwort, low nailwort, nailwort, stemless nailwort
	SIAN2	<i>Silene antirrhina</i>	catchfly, sleepy campion, sleepy catchfly, sleepy silene
	SIDR	<i>Silene drummondii</i>	Drummond cockle, Drummond's campion, Drummond's catchfly
Celastraceae	CESC	<i>Celastrus scandens</i>	American bittersweet
Chenopodiaceae	CHAL7	<i>Chenopodium album</i>	common lambsquarters, lambsquarters, lambsquarters goosefoot, white goosefoot
	CHBE4	<i>Chenopodium berlandieri</i>	netseed lambsquarters, pigseed goosefoot, pit-seed goosefoot, pitseed goosefoot
	CHLE4	<i>Chenopodium leptophyllum</i>	narrowleaf goosefoot
	CHPR5	<i>Chenopodium pratericola</i>	desert goosefoot
	CHSI2	<i>Chenopodium simplex</i>	giant-seed goosefoot, mapleleaf goosefoot
Cistaceae	HEBI2	<i>Helianthemum bicknellii</i>	hoary frostweed
Commelinaceae	TRBR	<i>Tradescantia bracteata</i>	bracted spiderwort, longbract spiderwort
	TROC	<i>Tradescantia occidentalis</i>	prairie spiderwort, spiderwort
Convolvulaceae	COAR4	<i>Convolvulus arvensis</i>	creeping jenny, European bindweed, field bindweed, morningglory, perennial morningglory, smallflowered morning glory
	EVNU	<i>Evolvulus nuttallianus</i>	prostrate evolvulus, shaggy dwarf morning-glory, shaggy dwarf morningglory, silver wild morningglory
Cupressaceae	JUCO6	<i>Juniperus communis</i>	common juniper, dwarf juniper
	JUSC2	<i>Juniperus scopulorum</i>	rocky mountain juniper, Rocky Mountain juniper
Cyperaceae	CAREX	<i>Carex</i>	sedge
	CABE2	<i>Carex bebbii</i>	Bebb's sedge
	CABR10	<i>Carex brevior</i>	brevior sedge, fescue sedge, shortbeak sedge
	CAFI	<i>Carex filifolia</i>	threadleaf sedge
	CAINH2	<i>Carex inops</i> ssp. <i>heliophila</i>	sun sedge
	CAPE42	<i>Carex pellita</i>	woolly sedge
	CARO5	<i>Carex rossii</i>	Ross sedge, Ross sedge, Rosss sedge, shortstemmed sedge
	ELPA3	<i>Eleocharis palustris</i>	common spikerush, creeping spikerush, spikesedge
Dryopteridaceae	WOOR	<i>Woodsia oregana</i>	Oregon cliff fern, Oregon woodsia
	WOSC	<i>Woodsia scopulina</i>	Rocky Mountain woodsia
Euphorbiaceae	CHAMA15	<i>Chamaesyce</i>	sandmat
	CHGL13	<i>Chamaesyce glyptosperma</i>	rib-seed sandmat, ribseed sandmat, ridgeseed spurge
	CHSE6	<i>Chamaesyce serpyllifolia</i>	thyme-leaf sandmat, thymeleaf sandmat
	EUBR	<i>Euphorbia brachycera</i>	horned spurge
	EUSP	<i>Euphorbia spathulata</i>	roughpod spurge, warty spurge
Fabaceae	AMCA6	<i>Amorpha canescens</i>	leadplant, leadplant amorpha
	ASTRA	<i>Astragalus</i>	astragalus spp., locoweed, locoweed species, milkvetch
	ASAG2	<i>Astragalus agrestis</i>	cock's-head, field milkvetch, purple milkvetch
	ASBI2	<i>Astragalus bisulcatus</i>	two groove milkvetch, two-groove milkvetch, twogroove milkvetch, twogrooved milkvetch

Family	Code	Scientific Name	Common Names
	ASCR2	<i>Astragalus crassicaarpus</i>	ground-plum, groundplum milkvetch
	ASFL2	<i>Astragalus flexuosus</i>	flexile milkvetch, pliant milk-vetch, pliant milkvetch
	ASGI5	<i>Astragalus gilviflorus</i>	plains milk-vetch, plains milkvetch
	ASGR3	<i>Astragalus gracilis</i>	Milkvetch, slender milkvetch
	ASLAR	<i>Astragalus laxmannii</i> var. <i>robustior</i>	prairie milkvetch
	ASLO4	<i>Astragalus lotiflorus</i>	lotus milk-vetch, lotus milkvetch, Low milkvetch, Milkvetch
	DALEA	<i>Dalea</i>	prairie clover
	DACA7	<i>Dalea candida</i>	slender white prairieclover, white dalea, white prairie clover, white prairie-clover, white prairieclover
	DAPU5	<i>Dalea purpurea</i>	Purple prairieclover, violet dalea, violet prairie clover, violet prairie-clover
	GLLE3	<i>Glycyrrhiza lepidota</i>	American licorice, licorice, wild licorice
	MELU	<i>Medicago lupulina</i>	black medic, black medic clover, black medick, hop clover, hop medic, nonesuch, yellow trefoil
	MEOF	<i>Mellilotus officinalis</i>	yellow sweet-clover, yellow sweetclover
	OXYTR	<i>Oxytropis</i>	crazyweed, locoweed
	OXSE	<i>Oxytropis sericea</i>	locoweed, Silky crazyweed, silvery oxytrope, white crazyweed, white locoweed, white pointloco
	PEAR6	<i>Pediomelum argophyllum</i>	silverleaf Indian breadroot, silverleaf scurfpea
	PECU3	<i>Pediomelum cuspidatum</i>	largebract Indian breadroot, tallbread scurfpea
	PEES	<i>Pediomelum esculentum</i>	breadroot scurfpea, Indian breadroot, large Indian breadroot
	PSTE5	<i>Psoralegium tenuiflorum</i>	scurfpea, slimflower scurfpea
	THRH	<i>Thermopsis rhombifolia</i>	goldenpea, prairie thermopsis
	VIAM	<i>Vicia americana</i>	American deervetch, American vetch
Grossulariaceae	RIAUV	<i>Ribes aureum</i> var. <i>villosum</i>	clove currant, golden currant
	RICE	<i>Ribes cereum</i>	wax currant, wax current
	RIHI	<i>Ribes hirtellum</i>	hairy-stem gooseberry, hairystem gooseberry
	RIOX	<i>Ribes oxycanthoides</i>	Canadian gooseberry
Hydrophyllaceae	ELNY	<i>Ellisia nyctelea</i>	Aunt Lucy, ellisia, false babyblueeyes, waterpod
Iridaceae	SIMO2	<i>Sisyrinchium montanum</i>	mountain blue eyedgrass, mountain blueeyed grass, strict blue-eyed grass, strict blue-eyed-grass
Lamiaceae	HEDR	<i>Hedeoma drummondii</i>	drummond falsepennyroyal, Drummond's false pennyroyal, Drummond's falsepennyroyal, Drummond's pennyroyal
	HEHI	<i>Hedeoma hispida</i>	false pennyroyal, falsepennyroyal, rough false pennyroyal, rough falsepennyroyal, rough pennyroyal
	MAVU	<i>Marrubium vulgare</i>	horehound, white horehound
	MOFI	<i>Monarda fistulosa</i>	mintleaf beebalm, Oswego-tea, wild bergamot, wildbergamot beebalm, wildbergamot horsemint
	MOFIM2	<i>Monarda fistulosa</i> var. <i>menthifolia</i>	mintleaf bergamot, wild bergamot, mintleaf beebalm, Oswego-tea
	SARE3	<i>Salvia reflexa</i>	blue sage, lambsleaf sage, lance-leaf sage, lanceleaf sage, Rocky Mountain sage, sage mint
Liliaceae	ALCE2	<i>Allium cernuum</i>	nodding onion
	ALTE	<i>Allium textile</i>	prairie onion, textile onion, wild onion
	CAGU	<i>Calochortus gunnisonii</i>	Gunnison mariposa lily, Gunnison's mariposa lily
	LEMO4	<i>Leucocrinum montanum</i>	common starlily, star-lily

Family	Code	Scientific Name	Common Names
Linaceae	LILEL2	<i>Linum lewisii</i> var. <i>lewisii</i>	prairie flax
	LIRI	<i>Linum rigidum</i>	orange flax, Stiff flax, stiffstem flax
Malvaceae	SPCO	<i>Sphaeralcea coccinea</i>	copper mallow, orange globemallow, red falsemallow, scarlet globemallow
Melanthiaceae	TOVEG (ZIVEG)*	<i>Toxicoscordion venenosum</i> var. <i>gramineum</i>	deathcamas, grassy deathcamas
Nyctaginaceae	MILI3	<i>Mirabilis linearis</i>	linearleaf four-o'clock, narrow-leaf four-o'clock, narrowleaf four o'clock, narrowleaf four o'clock, narrowleaf four-o'clock
Onagraceae	CASE12	<i>Calylophus serrulatus</i>	halfshrub calylophus, halfshrub sundrop, serrateleaf eveningprimrose, yellow sundrops
	GACO5	<i>Gaura coccinea</i>	scarlet beeblossom, scarlet gaura, Scarlet guara
	GAMO5	<i>Gaura mollis</i>	velvetweed
	OECA10	<i>Oenothera caespitosa</i>	tufted evening-primrose
	OECO2	<i>Oenothera coronopifolia</i>	crownleaf evening primrose, crownleaf evening-primrose, crownleaf eveningprimrose
	OENU	<i>Oenothera nuttallii</i>	Nuttall eveningprimrose, Nuttall's evening-primrose
Oxalidaceae	OXST	<i>Oxalis stricta</i>	common yellow oxalis, erect woodsorrel, sheep sorrel, sourgrass, toad sorrel, upright yellow wood-sorrel, upright yellow woodsorrel, yellow woodsorrel
Pinaceae	PIPO	<i>Pinus ponderosa</i>	blackjack pine, bull pine, pinabete, ponderosa pine, rock pine, western yellow pine
Plantaginaceae	PLPA2	<i>Plantago patagonica</i>	woolly Indianwheat, woolly plantain, woolly plantian, woolly Indianwheat, woolly plantain
Poaceae	AGSC5	<i>Agrostis scabra</i>	rough bent, rough bentgrass, ticklegrass
	AGST2	<i>Agrostis stolonifera</i>	carpet bentgrass, creeping bent, creeping bentgrass, redtop, redtop bent, seaside bentgrass, spreading bent
	ANGE	<i>Andropogon gerardii</i>	big bluestem, bluejoint, turkeyfoot
	ARPU9	<i>Aristida purpurea</i>	Purple 3-awn, purple three-awn, purple threeawn, red threeawn
	BOCU	<i>Bouteloua curtipendula</i>	sideoats grama
	BODA2	<i>Bouteloua dactyloides</i>	buffalograss
	BOGR2	<i>Bouteloua gracilis</i>	blue grama
	BOHI2	<i>Bouteloua hirsuta</i>	hairy grama
	BRAN	<i>Bromus anomalus</i>	nodding brome, nodding brome grass
	BRJA	<i>Bromus japonicus</i>	Japanese brome, Japanese brome grass, Japanese chess
	BRTE	<i>Bromus tectorum</i>	cheat grass, cheatgrass, downy brome, early chess, military grass, wild oats
	DASP2	<i>Danthonia spicata</i>	poverty danthonia, poverty oatgrass, poverty wild oat grass
	DILI2	<i>Dichanthelium linearifolium</i>	slim-leaf rosette grass, slimleaf panicgrass, slimleaf panicum
	DIOL	<i>Dichanthelium oligosanthos</i>	fewanther obscuregrass, Heller's rosette grass
	ELCA4	<i>Elymus canadensis</i>	Canada wildrye
	ELEL5	<i>Elymus elymoides</i>	bottlebrush squirreltail, squirreltail, western bottle-brush grass
	ELTR7	<i>Elymus trachycaulus</i>	slender wheatgrass, slender wild rye
	ELTRS	<i>Elymus trachycaulus</i> ssp. <i>subsecundus</i>	slender wheatgrass
	ELTRT	<i>Elymus trachycaulus</i> ssp. <i>trachycaulus</i>	slender wheatgrass
	FESAS	<i>Festuca saximontana</i> var. <i>saximontana</i>	Rocky Mountain fescue

Family	Code	Scientific Name	Common Names
	HECOC8	<i>Hesperostipa comata</i> ssp. <i>comata</i>	needle and thread
	HESP11	<i>Hesperostipa spartea</i>	porcupinegrass
	KOMA	<i>Koeleria macrantha</i>	junegrass, prairie Junegrass
	MUCU3	<i>Muhlenbergia cuspidata</i>	plains muhly
	MURA	<i>Muhlenbergia racemosa</i>	green muhly, marsh muhly
	NAVI4	<i>Nassella viridula</i>	green needlegrass
	PAVI2	<i>Panicum virgatum</i>	switchgrass
	PASM	<i>Pascopyrum smithii</i>	pubescent wheatgrass, western wheatgrass
	PIMI7	<i>Piptatherum micranthum</i>	little-seed mountain-rice grass, littleseed ricegrass, Piptatherum micranthum
	POCO	<i>Poa compressa</i>	Canada bluegrass, flat-stem blue grass
	POPA2	<i>Poa palustris</i>	fowl blue grass, fowl bluegrass
	POPR	<i>Poa pratensis</i>	Kentucky bluegrass
	SCPA	<i>Schedonnardus paniculatus</i>	tumble grass, tumblegrass, tumblegrass
	SCSCS	<i>Schizachyrium scoparium</i> var. <i>scoparium</i>	little bluestem
	SONU2	<i>Sorghastrum nutans</i>	Indiangrass
	SPCR	<i>Sporobolus cryptandrus</i>	sand dropseed
	SPHE	<i>Sporobolus heterolepis</i>	prairie dropseed
	VUOC	<i>Vulpia octoflora</i>	eight-flower six-weeks grass, pullout grass, sixweeks fescue, sixweeks grass
Polemoniaceae	COLI2	<i>Collomia linearis</i>	narrow-leaf mountain-trumpet, narrowleaf mountaintrumpet, slenderleaf collomia, tiny trumpet
	PHAL3	<i>Phlox alyssifolia</i>	alyssum-leaf phlox, alyssumleaf phlox, phlox
	PHAN4	<i>Phlox andicola</i>	prairie phlox
	PHHO	<i>Phlox hoodii</i>	Hood's phlox, spiny phlox
Polygalaceae	POLYG	<i>Polygala</i>	unknown Polygala species
	POAL4	<i>Polygala alba</i>	milkwoart (White), white milkwort
	POVE	<i>Polygala verticillata</i>	whorled milkwort
Polygonaceae	ERPA9	<i>Eriogonum pauciflorum</i>	few-flower wild buckwheat, fewflower buckwheat, manybranch eriogonum
	POCO10	<i>Polygonum convolvulus</i>	black bindweed, black-bindweed, climbing buckwheat, climbing knotweed, cornbind, dullseed cornbind, pink smartweed, wild buckwheat
	PODO4	<i>Polygonum douglasii</i>	Douglas' knotweed
	PORA3	<i>Polygonum ramosissimum</i>	bushy knotweed, tall knotweed, yellow knotweed, yellow-flower knotweed
Primulaceae	ANAR	<i>Anagallis arvensis</i>	pimpernel, scarlet pimpernel
	ANOC2	<i>Androsace occidentalis</i>	western rock jasmine, western rock-jasmine, western rockjasmine
	DOPU	<i>Dodecatheon pulchellum</i>	dark-throat shootingstar, darkthroat shootingstar, Southern shootingstar
Ranunculaceae	ANCY	<i>Anemone cylindrica</i>	candle anemone, cottonweed
	ANMUM3	<i>Anemone multifida</i> var. <i>multifida</i>	Pacific anemone
	ANPAM	<i>Anemone patens</i> var. <i>multifida</i>	cutleaf anemone, eastern pasqueflower

Family	Code	Scientific Name	Common Names
Rosaceae	AGST	<i>Agrimonia striata</i>	roadside agrimony, woodland grooveburr
	CEMO2	<i>Cercocarpus montanus</i>	alderleaf cercocarpus, alderleaf mountain mahogany, birchleaf mountainmahogany, mountainmahogany, true mountain mahogany, true mountainmahogany
	FRVI	<i>Fragaria virginiana</i>	thickleaved wild strawberry, Virginia strawberry, wild strawberry
	GETR	<i>Geum triflorum</i>	old man's whiskers, prairie smoke, prairiesmoke
	PHMO4	<i>Physocarpus monogynus</i>	mountain ninebark
	POHI6	<i>Potentilla hippiana</i>	horse cinquefoil, woolly cinquefoil
	POPE8	<i>Potentilla pensylvanica</i>	Pennsylvania cinquefoil, prairie cinquefoil
	PRAM	<i>Prunus americana</i>	american plum, American plum
	PRPUB	<i>Prunus pumila</i> var. <i>besseyi</i>	Great Lakes sand cherry, western sandcherry
	PRVIM	<i>Prunus virginiana</i> var. <i>melanocarpa</i>	black chokecherry, choke cherry
	ROACS	<i>Rosa acicularis</i> ssp. <i>sayi</i>	prickly rose
	ROAR3	<i>Rosa arkansana</i>	Arkansas rose, prairie rose, prairie wildrose, wild rose, wildrose (prairie)
	ROWO	<i>Rosa woodsii</i>	Wood's rose, woods rose, Woods' rose
	RUIDS2	<i>Rubus idaeus</i> ssp. <i>strigosus</i>	grayleaf red raspberry
Rubiaceae	GAAP2	<i>Galium aparine</i>	bedstraw, catchweed bedstraw, cleavers, cleaverwort, goose grass, scarthgrass, sticky-willy, stickywilly, white hedge
	GABO2	<i>Galium boreale</i>	northern bedstraw
Saxifragaceae	HERI	<i>Heuchera richardsonii</i>	alumroot, Richardson's alumroot
Scrophulariaceae	BEWY	<i>Besseyia wyomingensis</i>	Wyoming besseyia, Wyoming kittentail
	CASE5	<i>Castilleja sessiliflora</i>	downy paintedcup, Great Plains Indian paintbrush, Indianpaintbrush
	COPA3	<i>Collinsia parviflora</i>	blue-eyed Mary, littleflower collinsia, maiden blue eyed Mary, small-flower blue-eyed mary, smallflower blue eyed Mary
	PENST	<i>Penstemon</i>	beard tongue, beardtongue, penstemon
	PEAL2	<i>Penstemon albidus</i>	white penstemon
	PEAN4	<i>Penstemon angustifolius</i>	broad-beard beardtongue, broadbeard beardtongue, narrowleaf penstemon
	PEGR5	<i>Penstemon gracilis</i>	lilac penstemon, slender penstemon
	PEGR7	<i>Penstemon grandiflorus</i>	large beardtongue, largeflowered penstemon
	VETH	<i>Verbascum thapsus</i>	big taper, common mullein, flannel mullein, flannel plant, great mullein, mullein, velvet dock, velvet plant, woolly mullein
	VEPE2	<i>Veronica peregrina</i>	neckweed, purslane speedwell
Selaginellaceae	SEDE2	<i>Selaginella densa</i>	dense clubmoss, dense spike-moss, lesser spikemoss, small clubmoss
Solanaceae	PHLO4	<i>Physalis longifolia</i>	common groundcherry, long-leaf ground-cherry, longleaf groundcherry
	PHV15	<i>Physalis virginiana</i>	ground cherry (Virginia), lanceleaf groundcherry, Virginia ground-cherry, Virginia groundcherry
	SOTR	<i>Solanum triflorum</i>	cut-leaf nightshade, cutleaf nightshade
Ulmaceae	ULAM	<i>Ulmus americana</i>	american elm, American elm
Unknown Family	UNKFORBANN	<i>Unknown annual forb</i>	Unknown annual forb
	UNKFORB	<i>Unknown forb</i>	Unknown forb
Urticaceae	PAPE5	<i>Parietaria pensylvanica</i>	Pennsylvania pellitory

Family	Code	Scientific Name	Common Names
Verbenaceae	VEBR	<i>Verbena bracteata</i>	bigbract verbena, bracted vervain, carpet vervain, prostrate verbena, prostrate vervain
	VEST	<i>Verbena stricta</i>	hoary verbena, hoary vervain, tall vervain, Woolly verbena, wooly verbena
Violaceae	VINU2	<i>Viola nuttallii</i>	Nuttall violet, Nuttall's violet, yellow prairie violet
	VIPE2	<i>Viola pedatifida</i>	crow-foot violet, prairie violet

*ITIS recognizes a new name for this species, the synonym from the USDA plants database is given in parentheses.

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