GRASSLAND MONITORING TEAM STANDARDIZED MONITORING PROTOCOL

Version 7

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Background and Objectives

Grassland management goals in Minnesota, North Dakota, and South Dakota often include preservation or restoration of the historical native condition and providing habitat for wildlife. As endangered or declining ecosystems, remnants of tallgrass prairie are intrinsically important to preserve. Remnant and restored prairies in the northern Great Plains are threatened by encroaching invasive species, particularly cool-season introduced grasses and woody vegetation. The main focus of grassland management efforts is on protecting or enhancing the competitive ability of native plants. However, because we typically operate without clear objectives for prairie management and with little or no evaluation of management effects, there are considerable uncertainties about the most appropriate management tools and prescriptions.

In 2007, a multi-agency group of grassland managers and scientists formed the Grassland Monitoring Team (GMT). The group felt that a cooperative, standardized monitoring effort would improve our effectiveness at resolving uncertainties about grassland management. A collaborative effort will facilitate comparisons of data across ownerships and throughout the tallgrass prairie region of Minnesota. Our effort is focused on native prairie, but the methods could likely also be applied in restored areas.

In November 2007, several representatives from this group participated in a workshop with prairie ecologists and experts in adaptive management and modeling. At this workshop, we developed a rough framework for adaptive grassland management in Minnesota and the Northern Tallgrass Prairie Ecoregion of North Dakota and South Dakota. Generally, the adaptive management process involves defining a problem, defining potential management alternatives, predicting (modeling) the expected system response to those management alternatives, implementing the management and evaluating the results. Based on the monitoring data collected, future decisions can be adapted to best meet the goals of the project.

Our goal is to determine broad plant composition and structural changes over time in response to a suite of land management techniques including grazing, burning, and rest. These management alternatives are described in Appendix 1.

The partners in this project have overlapping goals, but it should be noted that each of us has some specific goals that are not addressed with this effort. Within the context of this project, the following objectives apply across all ownerships and participants.

- Maintain or increase the percentage cover of native prairie vegetation relative to invasive/exotic vegetation.
- Maintain the floristic diversity of native grassland ecosystems.
- Minimize the percentage cover of invasive/exotic vegetation.
- Maintain the structural diversity of native grassland ecosystems.

Because we ultimately want to assess the condition of grassland vegetation across tens of thousands of acres, the group selected a rapid assessment technique that represents an extensive, rather than an intensive, sampling approach. Rather than collecting detailed information on community composition, we selected variables that will help us detect broad trends. Each variable (indicator) is related to the prairie structure and composition objectives described above. To accommodate partners who were interested in more detailed information, we designed a tiered monitoring protocol with more detailed levels of data collection; however, everyone will collect the same basic information.

Sampling Design

The population of interest for this project is remnant tallgrass prairie in Minnesota as well as eastern North Dakota and South Dakota. The subset available for sampling (management unit) is a field of native prairie that will undergo one consistent treatment at any given point in time. Management units can include federal, state or private properties, and are under the management of a project partner. Because many remnant prairies in Minnesota are small, we do not have a minimum size requirement for management units.

Sample units are permanent transects, distributed randomly in the management unit at a density of one transect per 10 acres. Management units will have a minimum of five transects, regardless of size. Transects are 25-m long and 0.1-m wide, and subdivided into fifty 0.5-m long quadrats (Grant et al. 2005). A list of potential transects are established in the office, then field checked to ensure they meet the study criteria. Use a random point generator tool to establish transect starting points (Appendix 2). Each point should be at least 25-m from the edge of the management unit and at least 50-m from another point. Exclude areas that are obviously in a wetland or heavily wooded area, are more than 75% nonvegetated (e.g., rock pile), or that cross between systems (i.e., upland grassland, lowland grassland, and wet meadow, as defined in Appendix 4). Create enough points to have 1 per 10 acres plus a few extra in case you have to reject some during the field check. Use Excel or other software to generate a random compass bearing for each transect. If it is determined during the field check that the transect as assigned will violate rejection criteria, first try running transect in the opposite direction (180 degrees). If the transect needs to be moved, the protocol in Appendix 3 should be used.

Because permanently marking transects in prairie systems can be difficult, this is not a requirement of the project. It is acceptable to use GPS to relocate transects, though we strongly recommend use of a sub-meter accuracy GPS unit. If participants choose to permanently mark their transects, they should consider likely management actions at the site. Aboveground posts are an option on management units that will not be grazed. Ground-level markers such as buried timber nails will be less affected by management activities, but can be very time-consuming to relocate. Whisker markers can help with relocation but will not withstand a fire.

Management units will be sampled at least once every three years, from July through September. This time period was chosen because it is the period during which the greatest number of tallgrass prairie plants can be identified. A new management unit will be sampled before the three year management period, and then will remain on a three year monitoring cycle as long as it is in the project. Because of the three year cycle, it is possible for participants to stagger their management units to lessen the monitoring burden in any one year:

	2011	2012	2013	2014	2015	2016	2017
Management Unit 1	Monitor	Manage	Manage	Manage *-and-* Monitor**	Manage	Manage	Manage *-and-* Monitor
Management Unit 2		Monitor	Manage	Manage	Manage *-and-* Monitor**	Manage	Manage

**This monitoring event is used both as the post-management survey for the previous cycle, and as the pre-monitoring survey for the upcoming cycle.

Field Methods

The protocol provides three options (A, B, and C) that are hierarchical in terms of the level of detail collected on plant community composition (Table 1). All options specify collecting the same basic structural information. Complex options incorporate all features of the simpler options, so that the most basic set of data (Option A) will be collected at every management unit, regardless of which protocol option is used. Each variable is described below; for those that differ based on the protocol option used, Table 1 describes the level of detail required for Options A, B, and C. One possibility for participants using either Options A or B might be to collaborate with partners to do a thorough Option C survey at more infrequent intervals, e.g., every 9 years.

Typical series of events at a transect:

1. Use GPS to navigate to the transect starting point.
2. Run out a 25-m cloth tape, staking it at both ends to prevent shifting during data collection.
3. OPTIONAL: Take a photo oriented towards the transect center from both ends of the transect.
4. Collect VOR readings at the center point of the transect (12.5 m). We recommend doing this before anything else, because activity of observers can disturb the vegetation cover. VOR readings are collected at the center point due to potential trampling of vegetation when locating the transect starting point.
5. If using a two-person team, we find that an efficient approach is to have one person identify and call out the plant codes and plant species present in each quadrat. The other person acts as the data recorder and also measures litter depth as the team moves along the transect.
6. When you come to the end of the transect, walk slowly along either side of the tape looking for the indicator species within the wider transect buffer. The buffer is 1.5 m (a Robel pole length) on both sides of the standard belt transect, making it 25 m X 3 m. Record indicator species even if they were already recorded in the quadrats.

Equipment needed:

- Compass
- GPS
- VOR pole
- meter stick
- rebar/stakes
- meter tape
- map and list of azimuths/coordinates
- datasheets (with extra) or mobile data recorder (if available)
- scratch paper
- pencils
- personal gear
- camera if doing photo points

Structure

Visual Obstruction Reading (VOR). At the center-point of the transect (12.5 m), take a set of VOR readings from the four cardinal directions (N, E, S, W) using a VOR (Robel) pole. The VOR pole has alternating decimeters clearly marked along the length of the pole (Robel et al. 1970). The observer will take VORs at a height of 1 m and a distance of 4 m from the pole. **Record the lowest half-decimeter mark visible on the pole** (i.e., not completely obscured by vegetation). It is recommended that you record VOR before doing anything else that may disturb the vegetation structure (e.g., running the transect).

Litter Depth. Using a meter stick or other suitable measuring device, **record litter depth to the nearest cm** at 5-m intervals along the transect (5, 10, 15, 20, 25 m). Measure litter depth from the soil surface to the top of the horizontal lying litter layer (exclude leaning standing, etc. litter).

Composition

Plant groups. Record a plant group code for each quadrat along the belt transect, using the hierarchical list of plant groups provided (Appendix 8). This list has been carefully designed to allow roll up into various levels. It is not species dependent, which allows the methods to be used in any grassland system regardless of the invasives of concern.

Plant codes represent a spectrum that spans from native-dominated to invasive-dominated. The plant codes represent a hierarchical tree, which functions as a dichotomous key. Arrival at the final code for an individual quadrat involves making four sets of independent decisions:

- Native (Natives >50% cover) vs. Invasive (Invasives >50% cover)
- All Native vs. Mostly Native OR Mostly Invasive vs. All Invasive
- Herbaceous vs. Low Shrub vs. Tall Shrub
- Graminoid vs. Graminoid-Forb vs. Forb

Regarding the grass-forb breakdowns – in previous versions of this protocol, there were four categories to describe the grass/forb composition (<25%, 25-50%, 50-75%, >75%). This version reduces that to three categories (<25%, 25-75%, >75%). Four categories may be more sensitive to detect change, but there were serious concerns about observer bias with the four categories. In our experience, the ends of this spectrum are easy to identify, which will make the decision faster and more consistent when being applied in the field. Additionally, we felt that in good quality prairie there can be lots of variation in the grass/forb composition. Having this broader range for the middle code (25-75%) will fit the "good" prairie and either extreme would indicate a problem.

Some general tips about assigning plant groups:

- Use foliar cover, as opposed to canopy cover, to make plant code determinations. *Foliar cover* "subtracts out" the "blank" spaces while *canopy cover* "fills in the gaps" between leaves, branches, etc.
- Assign 900 code ("Other," for bare ground, animal mounds, rock pile, etc.) if >75% of the quadrat is unvegetated.
- If >25% of the quadrat is vegetated, use relative percentages within the vegetated portion of the quadrat to make plant code determinations.
- To distinguish between low and tall shrub, use current height not the potential height of the species.
- In determining native/invasive composition, use the list of Tier 1 and 2 invasive species provided (Appendix 5). Note that some of these invasive species are actually native to parts of the region.
- Remember that the four classes (native/invasive; all native (invasive)/mostly native (invasive); herbaceous/low shrub/tall shrub; grass/grass-forb/forb) are independent decisions. Therefore, you should include woody species when making the native/invasive decision. The only exception is that grass/forb ignores woody components.
- Include dwarf shrubs (e.g., prairie rose, lead plant) with the Low Shrub category.

Table 1 Description of monitoring variables collected at the three hierarchical levels of detail.

Data	Plot	Option A	Option B[1]	Option C
Invasive Species	**Quadrat level**	Record all Tier 1 invasives[2] present, and whether they are present (P) or dominant (D; >50% of the quadrat)	Record all Tier 1 invasives present, and whether they are present (P) or dominant (D; >50% of the quadrat)	Record all Tier 1 and Tier 2 invasives present, and assign into one of three cover classes (<10%, 10-50%, 51-100%)
	Transect level	Use checklist to record presence of Tier 1 invasives	Use checklist to record presence of Tier 1 and/or Tier 2 (optional) invasives	Use checklist to record presence of Tier 1 and Tier 2 invasives
Quality indicators	**Quadrat level**	n/a	n/a	Record all Tier 1 or Tier2 quality indicators[3] and assign into one of three cover classes (<10%, 10-50%, 51-100%)
	Transect level	Record presence of Tier 1 quality indicators	Record presence of Tier 1 and/or or Tier 2 (optional) quality indicators	Record presence of Tier 1 or Tier 2 quality indicators not already recorded in quadrats.
Other species	**Quadrat level**	n/a	Record dominant native species from a select list (optional)	Record any other species present and assign into one of three cover classes (<10%, 10-50%, 51-100%)
	Transect level	n/a	n/a	Record presence of disturbance increaser indicators[4]
Plant group score	**Quadrat level**	Assign plant group code (see Appendix 8)	Assign plant group code (see Appendix 8)	Assign plant group code (see Appendix 8)
	Transect level	n/a	n/a	n/a
Structure	**Quadrat level**	Litter depth at 5m intervals (5, 10, 15, 20, 25m)	Litter depth at 5m intervals (5, 10, 15, 20, 25m)	Litter depth at 5m intervals (5, 10, 15, 20, 25m)
	Transect level	VOR at 12.5 m	VOR at 12.5 m	VOR at 12.5 m

[1]Option B is not currently in use by any project participants. If new participants are interested in using this option, the protocol needs to be developed more thoroughly, including developing the “select” native species list.
[2]Tier 1 & 2 Invasives: See Appendix 5
[3]Tier 1 & 2 Quality Indicators: See Appendix 6
[4]Disturbance increaser indicators: see Appendix 7

Data handling, analysis, and reporting

The FWS Biological Monitoring and Database Team developed an Access database for this project. In addition to data entry capabilities, the relational database also has a couple of simple reporting functions that enable quick analysis of entered data at the end of each field season. The database will still be used to complete the adaptive management model portion of the project, but data entry and storage have now been moved to a central sharepoint site (see below). This site will eliminate the need to import data from separate sites into the central database.

A sharepoint site (https://connect.doi.gov/fws/Portal/grassland/SitePages/Home.aspx) has been established for the project. The most recent versions of protocols, datasheets, plant ID guides, etc. will be available at this site. Additionally, data entry for the project will be done through this site. Managers will be able to enter, edit and store their data through this site. Non-USFWS partners can access this site but will need to request a login.

Data entry should be completed and proofed each year by September 30th. Management recommendations and reports will be generated by October 10th, and therefore, no changes to the entered data can be made after this time.

Personnel requirements and training

Project coordinators are responsible for organizing training sessions, facilitating communication among the group members, generating transects for new management units, disseminating any changes to the protocol or database, and working with a statistician to analyze data.

Field office staff will be responsible for choosing management units in their work area, data collection, data entry, and ensuring data accuracy.

The protocol was designed to be used by field staff or seasonal employees with a working knowledge of tallgrass prairie plant species common in Minnesota. A training session will be provided as needed each year in late June or early July. Following the session, we will hold periodic quality assurance checks in the field by double-sampling a set of transects. This will be done fairly early in the season to allow time to correct inconsistencies among observers. We recommend that quality-assurance checks be held in conjunction with additional training in species identification.

References

Grant, T.A., E.M. Madden, R.K. Murphy, K.A. Smith, and M.P. Nenneman. 2004. Monitoring native prairie vegetation: The belt transect method. Ecological Restoration 22 (2):106-112.

Robel, R.J., J.N. Briggs, A.D. Dayton, and L.C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23(4):295-297.

Appendices

Appendix 1. Management Alternatives

Annual Management Cycle

Defining the annual management cycle is more complex than it seems. Management cycles are usually defined using the growing season. However, the limits of the management cycle for this project are imposed by our monitoring schedule and which management actions are captured by the July-August monitoring schedule. Generally, the annual management cycle will run from September 1st through August 31st (See below).

We chose August 31st as the end date for our management year because that is the end of the monitoring period for the three-year time step. Any management that happens after this will not be captured by the monitoring data already collected, but management after this date will be included in the next three-year time step period. One potential exception to this management cycle is in the third year when monitoring occurs before August 31. Any management done after monitoring in the third year, even if the management occurs before September 1, is counted towards the next management year as the effects of that management were not captured in the monitoring. As a result, we recommend applying a rest treatment in the fall of Year 3 following the monitoring period (see below).

We have moved to a state-and-transition (S-T) model for this project. With a S-T model, we will provide management recommendations for a given management unit based on its current condition. If participants follow these recommendations, we will be able to increase the rate at which we learn about the effectiveness of these treatments for maintaining or enhancing the native plant communities. Because it will take a few months of processing for us to output the recommendations from the model after the monitoring data has been entered, we recommend using the rest treatment in the fall of Year 3 to wait to see what the model recommendations will be for management. The recommendations provided will be three suggested treatments for the next three-year time step (e.g., “Graze, Rest, Rest” or “Burn, Rest, Graze”), but they are not suggestions for the order of treatment. A “Burn, Rest, Rest” recommendation would simply suggest that the management unit be burned once within the next three years. Because Rest is a common treatment that will likely be recommended at least once for each management unit in a three-year period, it would be a safe treatment to default to the fall of Year 3 before management recommendations are available for the next time step.

<table>
<tr><th>Year</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th></tr>
<tr><td>Set Up</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Monitor</td></tr>
<tr><td>1</td><td colspan="12">Apply Treatments to Management Unit</td></tr>
<tr><td>2</td><td colspan="12">Apply Treatments to Management Unit</td></tr>
<tr><td>3</td><td colspan="10">Apply Treatments to Management Unit</td><td colspan="2">Monitor</td></tr>
<tr><td>4</td><td colspan="4">Recommended Rest</td><td colspan="8">Apply Treatments to Management Unit</td></tr>
<tr><td>5</td><td colspan="12">Apply Treatments to Management Unit</td></tr>
<tr><td>6</td><td colspan="10">Apply Treatments to Management Unit</td><td colspan="2">Monitor</td></tr>
<tr><td>7</td><td colspan="4">Recommended Rest</td><td colspan="8">Apply Treatments to Management Unit</td></tr>
<tr><td>8</td><td colspan="12">Apply Treatments to Management Unit</td></tr>
<tr><td>9</td><td colspan="10">Apply Treatments to Management Unit</td><td colspan="2">Monitor</td></tr>
</table>

Burning

Prescribed burns and even wildfires generally have distinct boundaries, but prescribed burn units can frequently shift over time. A management unit should be considered burned if ≥ 50% of the vegetation in the management unit has been exposed to fire. Recognizing that prescribed burns or wildfires rarely affect or consume 100% of the vegetation in an area, this estimate of 50% would include areas that were exposed to the fire but for whatever reason may not have actually burned. Because fires can be extremely variable (and probably were historically), there is no intensity requirement for an area to be considered burned. Season of the burn should be recorded in the database as the fire date, but a burn at any time during the annual management cycle will qualify as a burn.

Management information is recorded in the database at the transect level; therefore, if there are transects within a management unit that were not exposed to the fire (due to the fire not reaching an area of the unit and not due to patchiness of the burn), the management information for these transects can be recorded separately. For each transect within a management unit that has been burned, the following information should be recorded in the database: start date, end date (in the case of a wildfire), weather (relative humidity, maximum temperature, wind speed) and fire intensity (unburned, scorched, lightly burned, moderately burned, heavily burned, not applicable; see sharepoint site for a definitions document). A comments field will also be available to record any other desired information.

Grazing

A management unit should be classified as grazed if ≥ 25% of the area or biomass in the unit has been impacted by livestock in some way. There are no limits on the number or type of animals or length of grazing, but we assume that participants in this project are interested in maintaining or enhancing the native plant communities. Therefore, grazing systems used should fall within a conservation philosophy.

Grazing is often a very patchy disturbance within a management unit. Therefore, a grazing treatment should always be assigned at the management unit level (not the transect level). The only exception to this would be if a manager was completely sure (likely due to logistical reasons, i.e., access was blocked somehow) that a portion of the unit (where some transects are located) was never visited by the animals for the entire management cycle. For each transect within a management unit that has been grazed, the following information should be recorded in the database: start date, end date, animal type and number of animals. If rotational grazing is used on a unit, then two separate entries/records will need to be made for each transect listing the separate start and end dates. A comments field will also be available to record any other desired information.

Combination of Burn and Graze Within One Annual Cycle

For this project, we hope to evaluate the impact of burning and grazing across separate years, as well as, the impact of burning and grazing within one annual cycle. We define this combination treatment as occurring when a burn and a graze event (as defined above) both occur within one annual cycle (Sept. 1^{st} – Aug. 31^{st}). This should capture most of the combination treatment effects for each growing season. The only combination treatment that will be missed by this is if a burn happens in the spring or summer followed by a grazing event after September 1^{st} of that calendar year. We ask participants either to refrain from using this combination or to simply realize that this combination effect will be missed by the model (i.e., interpreted as a burn in Management Year 1 and a graze in Management Year 2).

Patch burn grazing (PBG) will be considered under this combination treatment. The management unit should then be defined as the burn unit. Under the PBG system, the impact of grazing is not as easily estimated because the animals are not fenced on the unit. Therefore, if a participant is using PBG on a site, we ask them to do a little more work on the ground to assess the actual grazing impacts on the unit (i.e., whether > 25% of the area or biomass was impacted by the animals). This will need to be done annually for all the burn units, not just the unit burned in that year. The burn and grazing management information should be recorded as separate management records using the same fields described above.

Rest

A rest treatment can be classified at either the management unit or transect level. A rest treatment should be defined as no management actions taken on that unit or transect over the entire management cycle. A comments field will also be available to record any other desired information. Please use the comments field to record any smaller scale management actions that may have occurred on the site (e.g., weed spraying). If an entire management unit is hayed, it should not be included in the adaptive management model for that three year model period.

Appendix 2. Generating Transects

(updated 19 June 2012)

1. Create a new shapefile that excludes an area 25-m from the edge of the management unit. The transect will run in a randomly-assigned direction from the start point, so this prevents a transect from leaving the management unit. It also helps to prevent edge effects and allow for slight fluctuation in management boundaries.
    a. Select the management unit
    b. Buffer tool is found in ArcToolbox – Analysis tools – Proximity
    c. Fill in necessary fields in the Buffer Tool dialog
        - For distance, choose linear unit, and enter -25 meters to create a 25-m buffer inside the management unit boundary.
        - On very small or linear management units, it may be necessary to decrease the buffer to fit a minimum of 5 transects (e.g., to 15-m from the management unit edge). In this case, you would have to force the random azimuth to assure that the transect stays within the management unit.
2. Generate random transect starting points
    a. Select the buffered management unit
    b. Create Random Points tool is found in ArcToolbox – Data Management Tools – Feature Class
    c. Fill in necessary fields in the Random Point tool dialog
        - Be sure to use the buffer created in previous step as the constraining feature class
        - Will need one transect per 10 acres, plus some extras in case a transect must be rejected when visited in the field
        - Use 50-meters for the minimum distance allowed (forced spacing prevents two transects from crossing each other). On very small or linear management units, leave this blank or the tool will not generate enough points. Instead, force the spacing manually as you create points in the next step.
3. Create points
    a. Use a random number generator (e.g., in Excel) to create a list of random azimuths to assign to the points.
        - In Excel, the function RANDBETWEEN can be used, with the bottom and top as 0 and 359, respectively. Simply copy the function across many cells to get a list of random numbers.
    b. Either create a new feature class or create new points within an existing transect starting point feature class. Be sure it includes fields for Management_Unit, Trans_ID, and Azimuth. Be sure that the transect names match with the database.
    c. The points will have a number assigned by the random point generator – in the field, visit them in that order, ensuring that they do not meet any rejection criteria (p. 2 in protocol). Assign the Transect_ID once a transect is verified as acceptable in the field.

Appendix 3. Procedures for Moving a Transect

1. Flip the bearing of the transect 180 degrees. For example, if the initial transect bearing was 85 degrees, try running the transect 265 degrees. If the transect is still not within the target community after shifting the transect bearing 180 degrees, try the +90 degree bearing, then the +270 degree bearing.

2. If the 4 directions (in step 1) do not work, move the transect starting point 25 m from the initial starting point along the original bearing assignment. For example, if the 355 degree bearing (from the +270 degree adjustment) still falls in a non-target community, move the starting point 25 m in the 85 degree direction.

3. If step 2 is still unsuccessful, repeat step 1 at 25 m from the initial point (180 degree flip, +90, +270). For example, if 25 m from the initial starting point along the 85 degree bearing is within a non-target community, try moving 25 m out in a 85+180 = 265 degree bearing, then 85+90 = 175 degree bearing, then a 85+270 = 355 degree bearing.

4. If moving 25 m along the 4 bearings still falls within a non-target community, repeat step 3, but move 50 m.

5. If still unsuccessful after trying to move the starting point 50 m. Use a new random location from the extra coordinates created in the office or contact the project manager.

Notes on target communities:

While GMT monitoring targets upland grasslands, lowland grasslands, and wet meadows, many of the areas are naturally heterogeneous and will contain wetter depressions. Only move the transect if the area clearly crosses from one target community to another, or is in a non-target plant community. Do not move the transect if it includes areas that have shrubs as a result of lack of management (woody encroachment). Shrub swamps should be considered a different community and warrants moving the transect. Forested areas with >50% cover should be considered a different community and warrant moving the transect. Individual trees should not warrant moving the transect.

Appendix 4. Native Plant System Level Descriptions

(Excerpts from Minnesota Department of Natural Resources MNDNR. 2005. Field guide to the native plant communities of Minnesota: the Prairie Parkland and Tallgrass Aspen Parklands Provinces. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. MNDNR St. Paul, MN.)

Upland Grass

*Upland Prairie (UP) communities are herbaceous plant communities dominated by graminoid species, with a species-rich forb component that can approach codominance with the graminoids. The tall grass big bluestem (*Andropogon gerardii*) and the midheight grasses prairie dropseed (*Sporobolus heterolepis*) and little bluestem (*Schizachyrium scoparium*) are the most important graminoids. Indian grass (*Sorghastrum nutans*), a tall grass, and porcupine grass (*Stipa spartea*) and side-oats grama (*Bouteloua curtipendula*), both midheight grasses, are the most important associated graminoids. Sedges (*Carex *spp.) are sometimes common in UP communities but are typically a minor graminoid component. The most common and widespread woody species are the low semi-shrubs leadplant (*Amorpha canescens*) and prairie rose (*Rosa arkansana*), and the tall shrub wolfberry (*Symphoricarpos occidentalis*). Purple prairie clover (*Dalea purpurea*), heath aster (*Aster ericoides*) and stiff goldenrod (*Solidago rigida*) are common forbs. The main vegetation layer in UP communities is usually less than 40in (1m) high, although some forbs and the flowering stalks of the tall grasses exceed this height as the growing season progresses.*

Lowland Grass

<u>Northern Wet Prairie</u>*: Grass-dominated but forb-rich herbaceous communities, often with a strong shrub component, on somewhat poorly drained to very poorly drained loam soils formed in glaciolacustrine sediments, unsorted glacial till, or less frequently outwash deposits. Present primarily on level to very gently sloping sites. Flooded for brief periods at most; upper part of rooting zone is not saturated for most of growing season. Drought stress is infrequent, usually brief, and not severe. Fires were very frequent historically.*

<u>Southern Wet Prairie</u>*: Grass-dominated but forb-rich herbaceous communities on poorly drained to very poorly drained loam soils formed in lacustrine sediments, unsorted glacial till, or less frequently outwash deposits. Typically in slight depressions, sometimes on very gentle slopes. Flooded for brief periods at most; upper part of rooting zone is not saturated for most of growing season, but saturation usually persists in lower zone for much of season.*

Wet Meadow

<u>Northern Wet Meadow/Carr</u>*: Open wetlands dominated by dense cover of broad-leaved graminoids or tall shrubs. Present on mineral to sapric peat soils in basins and along streams.*

<u>Southern Basin Wet Meadow/Carr</u>*: Open wetlands dominated by dense cover of broad-leaved sedges. Typically present in small, closed, shallow basins isolated from groundwater inputs.*

<u>Prairie Wet Meadow/Carr</u>*: Open wetlands dominated by a dense cover of graminoids. Present in small, shallow depressions in the western and southern parts of the state.*

Appendix 5. Invasive species lists.

This list was developed by Robert Dana (MCBS, 2008). Note that some species on this list are native to parts of Minnesota, but all are considered invasive threats to the integrity of a remnant tallgrass prairie plant community.

Tier 1 Invasives

Code	Common Name	Scientific Name	Old Code
BROANN	Annual Bromes	*B. japonicus, tectorum, secalinus*	
AGRCRI	Crested Wheatgrass	*Agropyron cristatum*	
POACPX	Canada and Kentucky Bluegrass	*Poa compressa, pratensis*	
PHLPRA	Timothy	*Phleum pratense*	
BROINE	Smooth Brome	*Bromus inermis*	
ELYREP	Quack-grass	*Elytrigia repens*	
PHAARU	Reed Canary-grass	*Phalaris arundinacea*	
AGRGIG	Redtop	*Agrostis gigantea/stolonifera*	
EUPESU	Leafy Spurge	*Euphorbia esula*	
CIRVUL	Bull Thistle	*Cirsium vulgare*	
CARNUT	Musk Thistle	*Carduus nutans*	
CARACA	Plumeless Thistle	*Carduus acanthoides*	
CENSTO	Spotted Knapweed	*Centaurea stoebe subsp. micranthos*	CENMAC
LEUVUL	Ox-eye Daisy	*Leucanthemum vulgare*	CHRLEU
DAUCAR	Queen Anne's Lace	*Daucus carota*	
CORVAR	Crown-vetch	*Coronilla varia*	
LOTCOR	Birdsfoot Trefoil	*Lotus corniculatus*	
MEDSAT	Alfalfa	*Medicago sativa*	
TRIPRA	Red & Alsike clovers	*Trifolium pratense, hybridum*	
CIRARV	Canada Thistle	*Cirsium arvense*	CIRCAN
ARTABS	Absinthe Sagewort	*Artemisia absinthium*	
MELISP	Sweet Clovers	*Melilotus alba & officinalis*	
TRIREP	White Clover	*Trifolium repens*	
LINVUL	Butter-and-eggs	*Linaria vulgaris*	
PASSAT	Parsnip	*Pastinaca sativa*	
SONARV	Sow-thistle	*Sonchus arvensis*	
LONTAT	Tartarian Honeysuckle	*Lonicera tatarica*	
RHACAT	Common Buckthorn	*Rhamnus cathartica*	
FRAALN	Glossy Buckthorn	*Frangula alnus*	RHAFRA
ELAANG	Russian Olive	*Elaeagnus angustifolia*	
ULMPUM	Siberian Elm	*Ulmus pumila*	
ROBPSE	Black Locust	*Robinia pseudoacacia*	
FRAPEN	Green Ash	*Fraxinus pennsylvanica*	
ACENEG	Boxelder	*Acer negundo*	
ULMAME	American Elm	*Ulmus americana*	
POPDEL	Cottonwood	*Populus deltoides*	

Tier 2 Invasives

Code	Common Name	Scientific Name	Old Code
DACGLO	Orchard Grass	*Dactylis glomerata*	
SETASP	Foxtails	*Setaria glauca, viridis, faberi*	
FESELA	Meadow and Tall Fescues	*Festuca pratensis & elatior*	
PUCDIS	European Alkali-grass	*Puccinellia distans*	
CRETEC	Hawk's Beard	*Crepis tectorum*	
ARCMIN	Burdock	*Arctium minus*	
XANSTR	Cocklebur	*Xanthium strumarium*	
GRISQU	Curly-top Gum Weed	*Grindelia squarrosa*	
MEDLUP	Black Medick	*Medicago lupulina*	
BERINC	Hoary Alyssum	*Berteroa incana*	
SISALT	Tumble Mustard	*Sisymbrium altissimum*	
VERTHA	Common Mullein	*Verbascum thapsus*	
NEPCAT	Catnip	*Nepeta cataria*	
POTREC	Sulphur-flowered Cinquefoil	*Potentilla recta*	
POTARN	Silvery Cinquefoil	*Potentilla argentea*	
SALTRA	Russian Thistle	*Salsola tragus*	
KOCSCO	Summer-cypress	*Kochia scoparia*	
SILCSE	Smooth Catchfly	*Silene csereii*	
SILVUL	Bladder-campion	*Silene vulgaris*	
CONARV	Field Bindweed	*Convolvulus arvensis*	
CALSEP	Hedge Bindweed	*Calystegia sepium*	
LAPPSP	Stickseeds	*Lappula redowski & squarrosa*	
AMABLI	Prostrate Pigweed	*Amaranthus blitoides*	
SINARV	Charlock	*Sinapis arvensis*	
ERUGAL	Dog-mustard	*Erucastrum gallicum*	
TAROFF	Dandelion	*Taraxacum officinale*	
SAPOFF	Bouncing Bet	*Saponaria officinalis*	
CHERUB	Alkali Blite	*Chenopodium rubrum*	
RUMACE	Sheep Sorrel	*Rumex acetosella*	
PERMAC	Lady's Thumb	*Persicaria maculosa*	POLPER
RUMSPP	Dock	*Rumex patientia, crispus, stenophyllus*	
PLANSP	Common & American Plantains	*Plantago major & rugellii*	
CARARB	Siberian Pea-tree	*Caragana arborescens*	
SALALB	White Willow	*Salix alba*	
PINSYL	Scotch Pine	*Pinus sylvestris*	
MORALB	White Mulberry	*Morus alba*	

Appendix 6. Native indicator species lists.

The list was developed by Robert Dana and Fred Harris (MCBS, 2008) and includes conservative species that are sensitive to grazing and easily identified

Tier 1 Natives

Code	Common Name(s)	Scientific Name	Old Code
AMOCAN	Leadplant	*Amorpha canescens*	
ECHANG	Narrow-leaved Purple Coneflower	*Echinacea angustifolia*	ECHPAL
ASTCRA	Ground Plum, Buffalo-bean	*Astragalus crassicarpus*	
CORPAL	Bird's Foot Coreopsis	*Coreopsis palmata*	
LIAASP	Rough Blazing Star	*Liatris aspera*	
LIAPUN	Dotted Blazing Star	*Liatris punctata*	
SYMSER	Silky Aster	*Symphyotrichum sericeum*	ASTSER
CALSER	Toothed Evening Primrose	*Calylophus serrulatus*	
HEURIC	Alum Root	*Heuchera richardsonii*	
PEDESC	Prairie Turnip	*Pediomelum esculentum*	
ANEPAT	Pasque Flower	*Anemone patens*	
POTARGU	Tall Cinquefoil	*Potentilla arguta*	
PHLPIL	Prairie Phlox	*Phlox pilosa*	
DALCAN	White Prairie Clover	*Dalea candida*	
DALPUR	Purple Prairie Clover	*Dalea purpurea*	
PRERAC	Smooth Rattlesnakeroot	*Prenanthes racemosa*	
LILPHI	Wood Lily	*Lilium philadelphicum*	
ZIZAPT	Heart-leaved Alexanders	*Zizia aptera*	
LIALIG	Northern Plains Blazing Star	*Liatris ligulistylis*	
ZIGELE	White Camas	*Zigadenus elegans*	
TRABRA	Bracted Spiderwort	*Tradescantia bracteata*	
LIAPYC	Great Blazing Star	*Liatris pycnostachya*	
HELAUT	Sneezeweed	*Helenium autumnale*	
LYSQUA	Prairie Loosestrife	*Lysimachia quadriflora*	
ZIZAUR	Golden Alexanders	*Zizia aurea*	

Tier 2 Natives

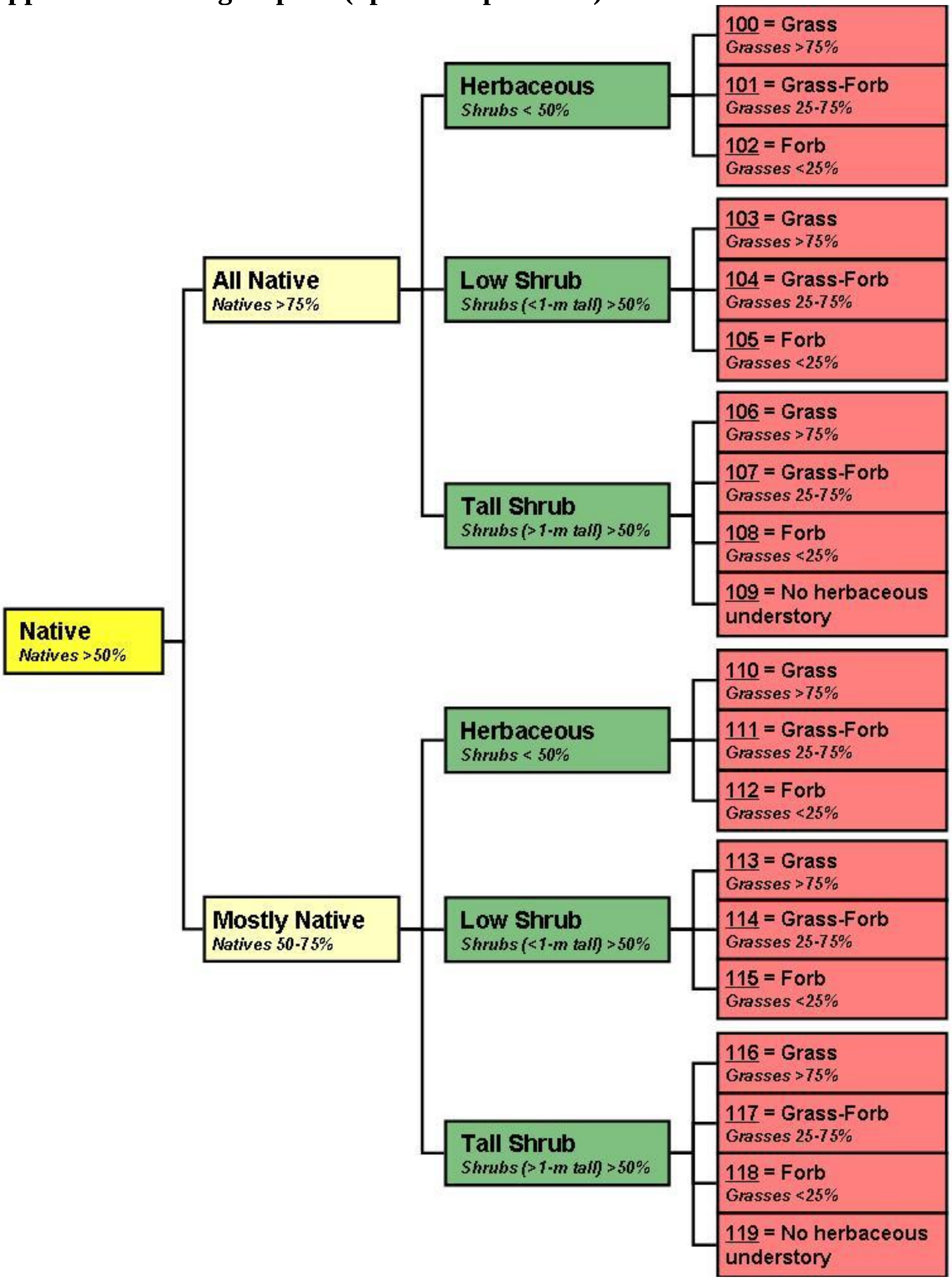
Code	Common Name(s)	Scientific Name	Old Code
AMONAN	Fragrant False Indigo	*Amorpha nana*	
GAIARI	Blanket Flower	*Gaillardia aristata*	
LIACYL	Few-headed Blazing Star	*Liatris cylindracea*	
SYMOBL	Aromatic Aster	*Symphyotrichum oblongifolium*	ASTOBL
SYMOOL	Sky-blue Aster	*Symphyotrichum oolentangiense*	ASTOOL
GENPUB	Downy Gentian	*Gentiana puberulenta*	
SOLSPE	Showy Goldenrod	*Solidago speciosa*	
ASCTUB	Butterfly Weed	*Asclepias tuberosa*	
SOLPTA	White Aster-like Goldenrod	*Solidago ptarmicoides*	
ASTADS	Prairie Milk Vetch	*Astragalus adsurgens*	
DELCAR	Prairie Larkspur	*Delphinium carolinianum subsp. virescens*	DELVIR
CASSES	Downy Paintbrush	*Castilleja sessiliflora*	
SYMLAE	Smooth Blue Aster	*Symphyotrichum laeve var. laeve*	ASTLAE
SILLAC	Compass Plant	*Silphium laciniatum*	

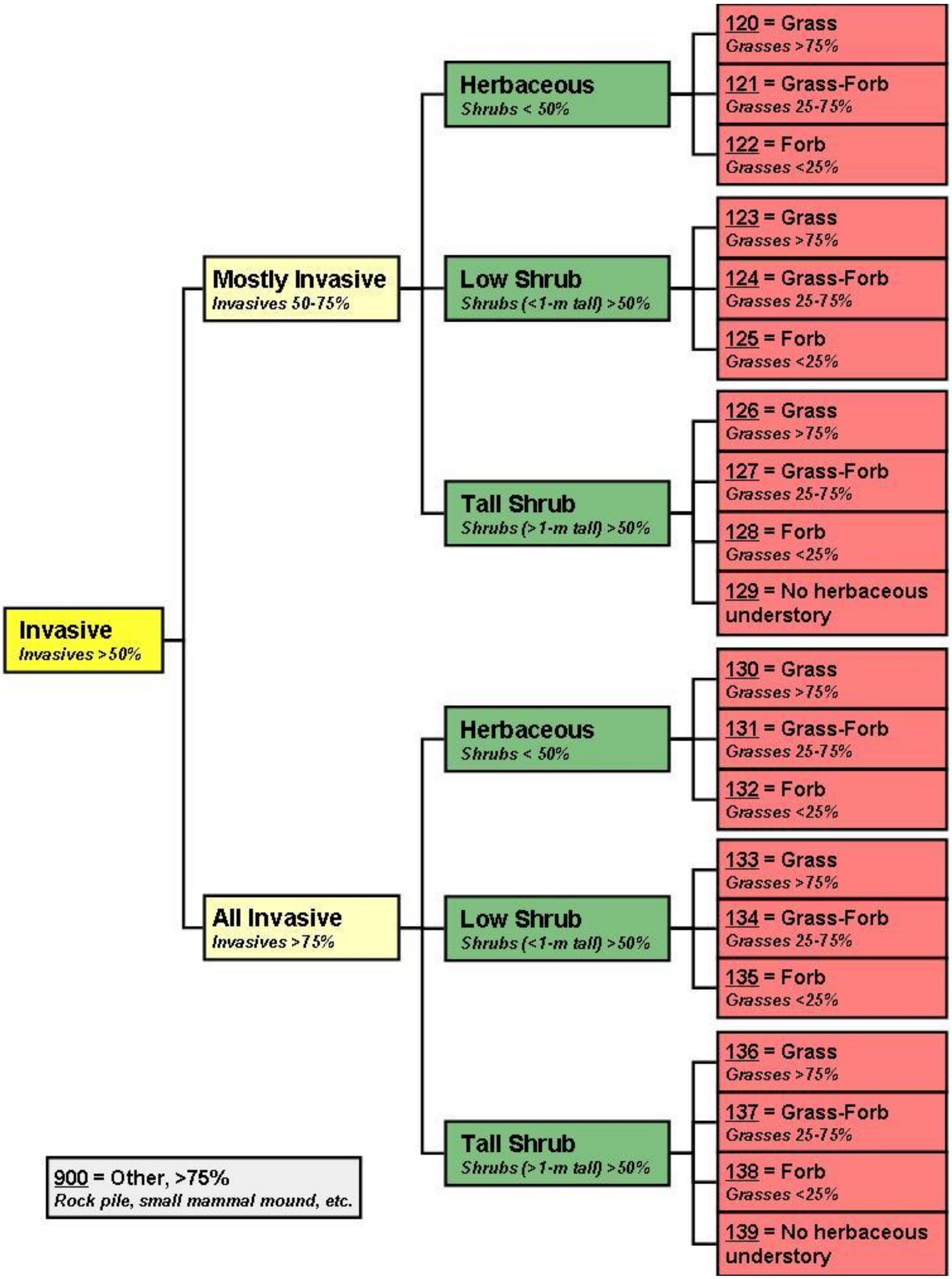
ASCOVA	Oval-leaved Milkweed	*Asclepias ovalifolia*	
AGOGLA	Glaucus False Dandelion	*Agoseris glauca*	
LATVEN	Veiny Pea	*Lathyrus venosus*	
ASCSPE	Showy Milkweed	*Asclepias speciosa*	
THADAS	Tall Meadow-rue	*Thalictrum dasycarpum*	
VERVIR	Culver's Root	*Veronicastrum virginicum*	
SOLRID	Riddell's Goldenrod	*Solidago riddellii*	
SYNNOV	New England Aster	*Symphyotrichum novae-angliae*	ASTNOV
DOEUMB	Flat-topped Aster	*Doellingeria umbellata*	ASTUMB
PEDLAN	Swamp Lousewort	*Pedicularis lanceolata*	
LYTALA	Winged Loosestrife	*Lythrum alatum*	
DICLEI	Leiberg's Panic Grass	*Dichanthelium leibergii*	PANLEI
MUHCUS	Plains Muhly	*Muhlenbergia cuspidata*	
CARFIL	Thread-leaved Sedge	*Carex filifolia*	
SORNUT	Indian Grass	*Sorghastrum nutans*	
SPOHET	Prairie Dropseed	*Sporobolus heterolepis*	

Appendix 7. Distubrance increaser indicator species list.

Code	Common name	Scientific Name
ACHMIL	Yarrow	*Achillea millefolium*
AMBART	Ragweed	*Ambrosia artemisiifolia*
AMBTRI	Giant Ragweed	*Ambrosia trifida*
BECSYZ	American Sloughgrass	*Beckmannia syzigachne*
CONCAN	Horseweed	*Conyza canadensis*
HORJUB	Foxtail Barley	*Hordeum jubatum*
IVAXAN	Marsh-elder	*Iva xanthifolia*
JUNARC	Baltic Rush	*Juncus arcticus (balticus)*
LEPDEN	Prairie Pepperweed	*Lepidium densiflorum*
PANCAP	Witchgrass	*Panicum capillare*
PLAPAT	Wooly Plantain	*Plantago patagonica*
RANCYM	Seaside Crowfoot	*Ranunculus cymbalaria*
SCIPAL	Pale Bulrush	*Scirpus pallidus*

Appendix 8. Plant group list (updated April 2009)




Invasive
Invasives >50%
Mostly Invasive
Invasives 50-75%
All Invasive
Invasives >75%
Herbaceous
Shrubs < 50%
Low Shrub
Shrubs (<1-m tall) >50%
Tall Shrub
Shrubs (>1-m tall) >50%
Herbaceous
Shrubs < 50%
Low Shrub
Shrubs (<1-m tall) >50%
Tall Shrub
Shrubs (>1-m tall) >50%
120 = Grass
Grasses >75%
121 = Grass-Forb
Grasses 25-75%
122 = Forb
Grasses <25%
123 = Grass
Grasses >75%
124 = Grass-Forb
Grasses 25-75%
125 = Forb
Grasses <25%
126 = Grass
Grasses >75%
127 = Grass-Forb
Grasses 25-75%
128 = Forb
Grasses <25%
129 = No herbaceous understory
130 = Grass
Grasses >75%
131 = Grass-Forb
Grasses 25-75%
132 = Forb
Grasses <25%
133 = Grass
Grasses >75%
134 = Grass-Forb
Grasses 25-75%
135 = Forb
Grasses <25%
136 = Grass
Grasses >75%
137 = Grass-Forb
Grasses 25-75%
138 = Forb
Grasses <25%
139 = No herbaceous understory
900 = Other, >75%
Rock pile, small mammal mound, etc.