Native Prairie Adaptive Management

Protocol Notebook

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INTRODUCTION

This document provides procedural and protocol guidance for operations of the joint USGS-USFWS Native Prairie Adaptive Management (NPAM) initiative. The origin of NPAM, along with the current project record, is recorded as an appendix to this document (Appendix A). NPAM is a framework for guiding annual decisions about the management of Service-owned native prairie parcels that are prone to invasions by non-native grasses, particularly smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*). The decision framework was designed to operate adaptively, in which experiences from past management actions are formally recorded and interpreted to improve the quality of decision making today. This approach to decision making is consistent with guidance developed by the Department of the Interior (Williams et al. 2009).

The NPAM framework relies on data collection, management action, and analytic pieces that interconnect and inform each other. The NPAM operation is sustained by many cooperators, who independently carry out decision making and monitoring on a diversity of land parcels under various degrees of invasion by exotic species. Cooperators differ in how they implement management, their degree of success in achieving a targeted action, and the range of uncontrollable environmental and logistic complications they face. NPAM was designed to accommodate these variations among sites and cooperators. However, its goal is to aggregate and interpret individual management outcomes under a common framework to improve conservation delivery for all cooperators. Therefore, some minimum protocols regarding the setup and operation of NPAM are necessary to insure that the information collected can be used to its fullest extent.

The main purpose of the protocol document is to provide operational guidance to the cooperating land managers and the project and database coordinators. Other audiences, such as the NPAM Advisory Team, NWRS program managers, and outside interested parties will find the document useful for understanding the overall architecture of the NPAM initiative. Details of the decision framework elements, including models, will be documented elsewhere: the NPAM final report and published manuscripts. The protocol document is intended to be continually revised as experiences change, as components of the framework are altered, and as familiarity with NPAM grows. At the time of this writing (February 2013), NPAM had been in place through three decision cycles, and between those cycles, elements of NPAM changed substantially. Further adjustments are to be expected as the program matures, and this document should be used to record these changes.

This document is organized into three broad sections. The first concerns the general design of the framework, how it is administered, definitions of terms, and criteria for participation. The second section treats all of the activities required in preparing a site for participation in NPAM. The last section covers the sequence of activities that occur over the course of an annual decision cycle, both at the site level and across the program at large.

1. GENERAL DESIGN

This section is divided into two subsections. The first describes the organization and administration of NPAM, including participant roles and responsibilities, definitions, and criteria for participation. The second subsection provides a brief summary of the technical components of NPAM, including predictive models, objective function, decision alternatives, and use of monitoring data for model weight updating.

1.1 GENERAL DESIGN | ORGANIZATION AND ADMINISTRATION

This subsection describes the organization and administration of NPAM, including participant roles and responsibilities, definitions, treatment alternatives, and criteria for participation.

1.1.1 GENERAL DESIGN | ORGANIZATION AND ADMINISTRATION | Organizational Design

NPAM operates at three levels of hierarchy. The *management unit* (defined below in section 1.1.3) occurs at the scale of a single native prairie parcel and is the basic unit to which treatments are applied and from which monitoring data are collected. At the *station* level, one individual (e.g., manager or biologist) typically oversees the entry of data and the administration of treatments to multiple units within a refuge or complex. At the *project* level, the data from individual units are processed, interpreted, and returned to station managers in the form of updated decision guidance for their units.

Some elements of NPAM are centralized, whereas others are distributed. All of the learning about system response to management takes place at the project level. Thus, database operations, GIS work, analysis, and identification of optimal actions are centralized operations that are managed by the Project Coordinator. Implementation of management recommendations, vegetation data monitoring, and data entry are activities that are distributed among the stations and management units.

1.1.2 GENERAL DESIGN | ORGANIZATION AND ADMINISTRATION | Roles and Responsibilities

Operation and maintenance of NPAM requires the coordinated effort of individuals in four specific roles: the Project Coordinator, the Database Coordinator, the network of cooperators, and the NPAM advisory team.

<u>FWS Project Coordinator</u>
Role: The Project Coordinator oversees the operation of NPAM and orchestrates the annual sequence of tasks that comprise the framework. The Project Coordinator addresses the needs and concerns of the cooperators and assures that protocols are understood and followed. The

Project Coordinator works closely with and guides NPAM-related work of a Database Coordinator.

Major Duties:

Communication/Outreach

1) Is the point of contact for Native Prairie Adaptive Management (NPAM).
2) Maintains communication with cooperators to advise cooperators of upcoming tasks, clarifications of protocol, instructions, etc.
3) Provides updates and reports to the participating FWS stations, Regional Office personnel, and other participating organizations.
4) Serves as the primary liaison with outside agencies and organizations to address needs of the project and the participating FWS stations.
5) Provides annual updates and project summaries to the Advisory Team.

Coordination/Oversight

1) Facilitates day-to-day operations of the project.
2) Ensures that cooperators are kept informed and receive timely reminders of critical steps in the process.
3) Takes proactive measures to facilitate continuity of project operations by establishing open dialogue with incoming staff when staff turnover occurs at a station.
4) Coordinates data collections from participating FWS stations in multiple Regions.
5) Receives annual monitoring data and communicates regularly with the Database Coordinator and project cooperators to assure data quality is maintained and schedules are kept.
6) Disseminates information and communicates with stations regarding results, project needs, and changes to the database, models, or monitoring protocol.

Training/Support

1) Handles routine questions from the field.
2) Coordinates training opportunities for FWS employees related to NPAM.

Data Management/Technical Support

1) Confers with the NPAM Advisory Team to address complex issues or questions.
2) Processes incoming monitoring data and distributes the recommended management actions to cooperators on August 31 of each year.
3) Serves as a clearinghouse and repository for information about the project.

<u>FWS Database Coordinator</u>

Role: The Database Coordinator provides effective oversight and maintenance of the highly interrelated data management system and geospatial tasks related to NPAM.

Major Duties:

Data Management

1) Holds primary responsibility for GIS support and operation of the data management system.
2) Holds primary responsibility for generating and maintaining locations of monitoring transects in GIS. Employs customized tools to generate new belt-transects to ensure uniform sampling density and distribution across all management units.
3) Maintains the web-based data entry tool.
4) Creates file structures to streamline data archiving, storage, and backup, including maintenance of distinct databases for: 1) spatial data on belt-transects and management units for all stations; 2) raw data on vegetation sampling and management actions for each management unit; 3) processed data used for updating of decision model weights and indexing of optimal management actions; and 4) other ancillary data as needed, including phenological observation data.
5) Prepares an annual archive of monitoring and management data collected project-wide.
6) Communicates regularly with station contacts to ensure data quality standards are met.

Technical Support

1) Provides the following outcomes and products: 1) operational adjustments and programming revisions to the data management system based on cooperator feedback; 2) training of FWS personnel and trouble-shooting assistance for the NPAM data management system; and 3) assistance to FWS cooperators with a multitude of geospatial tasks critical to project operations.
2) Collaborates with field stations to accomplish changes and updates prior to each field season, including responding to requests for additions, replacements, and adjustments to management units while ensuring data quality, consistency and subscription to project standards.
3) Collects supplementary geospatial data that will enrich post-hoc analysis of the data.
4) Works with the NWRS Inventory and Monitoring group and FWS IT staff as needed to maintain functionality of the web-based data entry tool and its connection to the Access host database.

Data Aggregation and Assembly

1) Monitors progress of annual data entry by field stations and resolves issues as they arise in order to assure timely completion of data entry by established deadlines.
2) Assists the Project Coordinator with technical aspects on annual data roll-up, including archiving databases, error checking and correction, preparation of data for analysis, updating model confidence weights, and generation of decision recommendations.

<u>FWS Cooperators</u>

Role and Identity: Cooperators are the “boots on the ground” aspect of the project. Cooperators are participating refuges or complexes with one or more management units enrolled in the NPAM project. Participation is voluntary and cooperators agree to embrace the

cooperative learning philosophy of the project. Each cooperator has a designated point-of-contact for the NPAM project.

Responsibilities:

1) Identify and enroll management units.
2) Consider annual recommended management actions and then make management decisions and apply management actions.
3) Conduct annual monitoring.
4) Enter and error-check monitoring and management data.
5) Keep with the annual timeline.
6) Inform the NPAM Project Coordinator of changes in the point-of-contact and of any issues in implementation of NPAM.

Advisory Team

Role and Identity: The NPAM project is a culmination of years of critical thinking and effort by refuge staff, their colleagues, and their partners. The resource issue being addressed is complex and the stakes are high, making it imperative that the problem continue to receive critical attention by individuals who have the background and understanding to ensure that the goals of the project are being met. An advisory team comprised of such individuals will provide this continuity by periodically evaluating the project and making recommendations for its improvement or adaptation in response to new challenges. The advisory team is thus the mechanism for assessing and implementing institutional ("double-loop") learning that often occurs in an adaptive management effort (Williams et al. 2009). The advisory team should be co-chaired by the NPAM Project Coordinator and a USGS NPAM principal investigator. The co-chairs should populate the team with other members as appropriate, but it should include representatives from field stations in each Service region. Additional team members may include representatives from the Inventory and Monitoring program and experts from outside of FWS or USGS.

Major Duties:

1) Periodically evaluate progress (technical learning) occurring under NPAM to ensure that the project does not waver from its vision of achieving an enhanced understanding of process-oriented management of native prairies through the coordinated efforts of multiple refuges.
2) Institutional or "double-loop" learning may become necessary at some point and the Advisory Team should be the driving force behind if and how that need is addressed.
3) The Advisory Team is not involved with day-to-day operations of NPAM, but is available as a sounding board or "think-tank" for non-routine issues identified by the NPAM Project Coordinator.

1.1.3 GENERAL DESIGN | ORGANIZATION AND ADMINISTRATION | Definitions

Native Prairie

Native prairie (also called remnant prairie or native sod) is unbroken grassland with no history of cultivation. Plant composition can vary widely depending on the land use history and various geological and climatological factors that span the project area of the NPAM. Tools to identify native prairie areas on NWRS lands include aerial imagery, historical management records (e.g., RIP (Resource Inventory Protocol) cards), historic maps, personal or local knowledge of the site, soil testing, etc.

Management Unit

Cooperators in the NPAM submit native prairie 'management units' for participation. A management unit is the smallest parcel of land receiving only a single management treatment at any time over its entire extent. For example, a management unit might be an entire 80-acre WPA or it might be a 120-acre fenced parcel within a larger tract (refuge or WPA). The participating management unit must contain native sod, but it need not entirely consist of native sod; that is, the management unit may include areas of native sod as well as areas with a cultivation history. Only the native sod portion of the unit will be relevant to the NPAM project.

Management Year

The 'management year' for the NPAM project starts on September 1 and ends August 31. Management treatments that occur during the fall or spring are considered within the same management year. Vegetation data are collected in June, July, or August of a given management year, and are used to determine the management recommendations for the following management year.

Grass Type

Each management unit enrolled in NPAM is given a permanent designation by the cooperator as one of two grass types, mixed-grass or tallgrass prairie, perhaps in consultation with the NPAM Project Coordinator. In most cases, determination of grass type is clear on the basis of location of the site, but other criteria (see below) may need to be considered for units close to the biome border in the eastern Dakotas. Note that mixed-grass and tallgrass units may occur within the same refuge complex, meaning that the cooperator must be cognizant that sets of management alternatives, data elements to be collected, and management recommendations will differ according to grass type of the unit.

Ecological and Physiological Criteria for Determining Grass Type

Mixed-Grass Prairie

- Location – Participating stations with units in the mixed-grass prairie include areas east of the Missouri River, but west of the Red River Valley and Prairie Coteau in North Dakota and South Dakota; and north-central and north-eastern Montana, north of the Missouri River and east of the Rocky Mountains.

- Climate – The climate of this region is notable for long, cold winters, and dry, hot summers with areas further west being drier than the eastern areas bordering the tallgrass prairie. The entire region is subject to frequent droughts and wet cycles.
- Soils – The soils of the mixed-grass prairie are glacial till with varying soil associations and ecological sites.
- Flora – The native flora of this region includes cool-season graminoid species such as needlegrasses, wheatgrasses, Junegrass, sedges, and warm-season species such as blue grama, sideoats grama, and bluestems. Small shrubs such as western snowberry, rose, and leadplant also occur, along with numerous forbs especially in Asteraceae and Fabaceae.

Tallgrass Prairie

- Location – Participating stations with units in tallgrass prairie are found in western Minnesota and the eastern Dakotas.
- Climate – The climate of the region is similar to the mixed-grass prairie, but with slightly higher annual average precipitation (20-30 inches per year).
- Soils – The region was heavily influenced by the most recent glacial event, with a deep mantle of drift present in most areas.
- Flora – The flora is typically dominated by graminoid species but with a rich forb component that can approach co-dominance with the grasses. Tallgrass plant communities are variable and reflect the soils and topography at a given site; tall grasses will predominate on mesic sites, while mid-height and short grasses become more prevalent on drier sites. Prominent species include tall grasses such as big bluestem and Indian grass, while common mid-height grasses include little bluestem, prairie dropseed, side-oats grama, and porcupine grass. Woody species include leadplant, prairie rose and snowberry. Purple prairie clover, heath aster, and stiff goldenrod are common forbs.

<u>Cool-Season Window</u>

The cool-season window is a phenological attribute that is considered only for tallgrass prairie units under NPAM (see the provisional model described by Willson and Stubbendieck (2000) for relevance and motivation). It is the period when cool-season invasive grass species are actively growing and vulnerable to damage via select management actions, but warm-season grass species are not active and are thus less susceptible to damage via the same actions. Two such windows of opportunity occur each management year: one in the fall and the other in the spring. Due to the large geographic area of the NPAM project, phenological cues, rather than calendar dates, are used to define when the windows begin and end. The dates of occurrence will vary by location and year and so must be determined each fall and spring of each management year at each station.

Fall window – The phenological cue for the beginning of the fall window is “re-green up” when warm-season grass species have gone to seed, but cool-season invasive grass species have resumed tiller growth after the summer dormant period. The fall window will end after the first killing frost (most of the plants are turning yellow). Typically this window lasts 4-6 weeks and

occurs within a period from mid-September to the end of October, depending on the year, weather, and location.

Spring window – The phenological cue for the beginning of the spring window is when smooth brome is in the 5-leaf stage. The spring window closes when smooth brome inflorescences are visible. The spring window captures the rapid growth phase of cool-season invasive plant species while excluding the growth and reproductive stages of native warm-species species that occurs later in the season. Typically this window lasts about 30 days and occurs within a period from early May to mid-June, depending on the year, weather, and location.

NPAM definitions of "within the window" and "outside of the window" by phenological cues are as follows:

	Within Window	**Outside Window**
Fall	>50% of warm-season native grasses have gone to seed AND >25% of cool-season invasive grasses are fall green-up plants	>50% of warm-season native grasses are still active (*before window*) OR >75% of cool-season invasive grasses have senesced (*after window*)
Spring	>50% of smooth brome has at least 5 leaves AND <50% of smooth brome has visible inflorescences	>50% of smooth brome has fewer than 5 leaves (*before window*) OR >50% of smooth brome inflorescences are visible or have passed (*after window*)

1.1.4 GENERAL DESIGN | ORGANIZATION AND ADMINISTRATION | Treatment Alternatives

Mixed-Grass

Rest

Rest designates the lack of any defoliation treatment (i.e., *Graze* or *Burn*) applied to the management unit during the management year. Special, targeted treatments (e.g., spot

herbicide treatments or clipping) within the management unit may occur and the unit is still considered to have received a *Rest* treatment.

Graze
Under NPAM, the *Graze* treatment is defined as the targeted use of grazing ungulates as the *single* form of defoliation that occurs during a management year. In general, any timing, duration, intensity (stocking rate), or grazing species that targets the rapid growth phase of cool-season invasive plant species and is considered consistent with best management practices for native prairie ecosystems is permitted under NPAM; see Appendix B for guidelines and motivation for applying prescribed grazing in prairie environments.

Burn
Under NPAM, the *Burn* treatment is defined as the application of fire as the *single* form of defoliation that occurs during a management year. In general, any timing, intensity, or method of application that is considered consistent with best management practices for native prairie ecosystems is permitted under NPAM; see Appendix B for guidelines and motivation for burning in prairie environments.

Burn/Graze
Under NPAM, the *Burn/Graze* treatment is defined as the use of the *Graze* and the *Burn* treatments, as defined above, in the course of a single management year. The burn and graze actions may both occur in the fall, both occur in the spring, or occur in different seasons. Typically, the burn action precedes the graze action, but reversal of these actions can occur. Implementation of the burn and graze actions should be carried out as described above. See Appendix B for guidelines and motivation for using burn/graze combination treatments in prairie environments.

<u>Tallgrass</u>
Rest
Rest designates the lack of any defoliation treatment (i.e., *Graze within window*, *Burn within window*, or *Defoliate*) applied to the management unit during the management year. Special, targeted treatments (e.g., spot herbicide treatments or manual pulling) within the management unit may occur and the unit is still considered to have received a *Rest* treatment.

Graze within window
Under NPAM, the *Graze within window* treatment is defined as the use of grazing ungulates within the cool-season window as the *single* form of defoliation that occurs during a management year. The "within cool-season window" condition is satisfied if the seasonal-specific conditions are met as described below.

- Fall window
    - Putting animals on the unit
        - Animals may be placed on the unit within 2 weeks prior to the start of the window, or at any time after the start of the window
    - Length of the graze

        - Assure that the graze period within the window is at least 2 weeks long or covers the entire length of the window.
    - Removing animals from the unit
        - Animals may be removed at any time within 2 weeks prior to the close of the window, or at any time up to 4 weeks after the close of the window.
- Spring window
    - Putting animals on the unit
        - Animals may be placed on the unit at any time prior to or after the start of the window.
    - Length of the graze (*same as Fall window*)
        - Assure that the graze period within the window is at least 2 weeks long or covers the entire length of the window.
    - Removing animals from the unit
        - Animals may be removed at any time within 1 week prior to the close of the window, or at any time up to 2 weeks after the close of the window.

Within these side-boards, any timing, duration, intensity (stocking rate), or grazing species that is considered consistent with best management practices for native prairie ecosystems is permitted under NPAM; see Appendix B for guidelines and motivation for applying prescribed grazing in prairie environments.

Burn within window

Under NPAM, the *Burn within window* treatment is defined as the application of fire within the cool-season window as the *single* form of defoliation that occurs during a management year. Within this window, any timing, intensity, or method of application that is considered consistent with best management practices for native prairie ecosystems is permitted under NPAM; see Appendix B for guidelines and motivation for burning in prairie environments.

Defoliate

Under NPAM, the *Defoliate* treatment is any graze or burn action that does not meet the "within cool-season window" criteria outlined above. The *Defoliate* classification also includes haying actions that occur at any time of the year. For all these actions, any timing, intensity, or method of application that is considered consistent with best management practices for native prairie ecosystems is permitted under NPAM; see Appendix B for guidelines and motivation for applying these treatments in prairie environments.

Valid combinations of treatments

Within a management year, more than one management action may be carried out on a unit; however, only some combinations of treatments are valid in NPAM. Valid multiple treatments include: multiple grazes within the window, multiple burns within the window, and multiple defoliations (i.e., grazes and burns outside of the window, or hays). Other combinations of treatments (e.g., graze within window and burn within window; graze within window and defoliate; or burn within window and defoliate) are not valid and should be avoided. Data from units with invalid combinations of treatments may not be included in the NPAM model weight

updating process for that year, but monitoring data should still be collected and entered in the database for these units.

1.1.5 GENERAL DESIGN | ORGANIZATION AND ADMINISTRATION | Criteria for Participating/Withdrawing

Because the focus of NPAM is the gain of understanding in how to improve management on unbroken, native prairie, selection of units for participation in NPAM should be considered carefully. This section establishes minimum criteria for the selection and modification of units enrolled in the program. Furthermore, delivery on conservation objectives can only be reached if cooperators are full participants in the program. Therefore, this section also outlines expectations of cooperator participation.

Adding New Units

For any unit nominated for inclusion in NPAM, the cooperator will complete a background questionnaire that describes basic physical attributes of the unit, details of its management history, and any limitations foreseen in applying actions from the NPAM treatment menu. The questionnaire is due by February 15 and is sent to the Database Coordinator, where the information is recorded in a database. The questionnaire is described in detail in section 2.1.3.

Management Unit Characteristics

Management History - The only unacceptable management history is one that includes a history of tillage farming, where the sod is no longer native. NPAM may include sandy soil units where there was a history of short-duration farming prior to the 1930s, but only in cases where it is possible to confirm that the native prairie state has recovered sufficiently so as to be similar to other prairie units enrolled in NPAM near the upper end of intactness. Inclusion of such exception units must be done with great care to ensure that the integrity of the unit has not been permanently altered in any way.

Size – No size limitations are explicitly established, although it is the Project Coordinator's responsibility to carefully review all new management units for size appropriateness. Maximum unit size is determined by the field station's ability to uniformly apply a single treatment across the entire unit. When units seem excessively large, it is the Project Coordinator's role to follow up with the field station to confirm that the NPAM treatments could always be applied across the entire unit. If not, then appropriate changes should be made to the unit, including subdivision into smaller, more manageable units. In contrast to large units, small units may contain less than 10 acres of native sod. No minimum unit size is formally established, but the native sod portion of the unit should be large enough to accommodate no fewer than four, non-overlapping belt transects.

Land Features - No formal constraints related to features of the land precludes a unit from the NPAM project. However, units are thoroughly examined during the nomination process to help identify and mitigate potential issues via site selection, boundary placement, and transect

location. Units with significant wet meadow and wet prairie components are discouraged from inclusion, particularly if portions of these units would be routinely submerged during monitoring. The primary invasive species targeted by NPAM are smooth brome and Kentucky bluegrass, so units that are dominated by other invasive species are discouraged (e.g., reed canarygrass).

Logistical Constraints - Units with treatment limitations can be included. However, their utility in the overall decision framework will be limited, and the decision recommendations that are generated for them may not be meaningful. For these reasons, cooperators are discouraged from submitting units with treatment limitations. Examples of treatment-limited units may include the following:

1) Adjacency to human development (e.g., towns or major highways) may limit the ability to use prescribed fire.
2) Lack of boundary fence, adequate water resources, or access to cattle may limit the use of grazing.
3) Units immediately adjacent to other NPAM units may have limited ability to apply a treatment independently of what occurs on the adjacent unit.
4) Ongoing research or other experiments may limit the flexibility with which a unit can be treated.

All treatment limitations should be noted on the background questionnaire.

Circumstances for Modifying a Unit

Splitting Units - Field stations may decide to split a unit during the nomination review process or after some management experience under NPAM. The main justification for splitting a unit is inability to apply a single treatment uniformly across the entire unit in any year. Ordinarily, the splitting of a unit will not require completion of new background questionnaires for each newly created unit, unless the split coincides with some physical feature, a management limitation, or distinct management histories.

Combining Units – There may be rare circumstances that compel a field station to consider combining two or more units. In such cases, the candidate combined unit should be assessed for feasibility of treatment application and monitoring just as would apply to any other unit. A background questionnaire for the newly created unit should be completed to resolve among differences in physical features and management histories of the original units.

Dropping Units - Circumstances that result in the field station's decision to drop a unit may involve the following: (1) persistently flooded units; (2) units with severe treatment limitations; (3) units with no sign of native species remaining; or (4) units where the primary invasive species is not smooth brome or Kentucky bluegrass. Most of these situations can be avoided by reviewing the background questionnaire and discussing the unit in detail with the field station prior to inclusion in NPAM. But in some cases, the field station's knowledge of the unit is limited until some experience in managing and monitoring the unit under NPAM has been gained. Loss of staff or resources that prevent a station from completing the NPAM activities

on a unit for a temporary period of time will not result in permanently dropping those units; however, continuity of participation is highly valued and such restrictions need to be communicated with the Project Coordinator.

Circumstances for Replacing a Transect

Though measures are taken to place transects in appropriate locations, circumstances may exist or arise that necessitate a field station to replace an existing transect. Some circumstances may include a transect that is not located in native sod, bisects a fence line, encounters a patch of trees, overlaps a wetland, or is located in an area with a chronic high water issue resulting in being repeatedly under water (full or partial) during the monitoring season. Surplus transects have been generated to serve as replacements when deemed necessary. These replacement transects are obtained from the Database Coordinator upon request from a station.

Deadlines for Unit or Transect Modifications

Adding, Dropping, or Replacing Units - Revisions to units are due February 15 to the NPAM Database Coordinator. This late-winter deadline is used to provide the Database Coordinator with requisite time to generate transects, add the unit to the database, and seek follow-up information, if needed.

Unit Boundary and Transect Modifications - Requests for boundary adjustments to existing units or changes to existing transects may occur in mid to late summer when cooperators are in the field and have identified treatment and sampling issues. These requests for modifications are accommodated whenever possible. These types of changes are done as needed rather than during set deadlines, but the earlier the issue can be caught and fixed, the better.

Participation Commitments of Cooperators

1) Agreement to provide GIS spatial elements and management background questionnaire.
2) Commitment to collect annual monitoring data, record management activity, and enter information into the data entry interface.
3) Adherence to defined sideboards of management activities; otherwise, recording of departure from sideboards.
4) Observation of annual deadlines for submitting new units, vegetation monitoring, data entry, and management action.
5) Requisite consideration of the annual recommended management action for each unit.
6) Notify Project Coordinator and Database Coordinator of any changes to transects (i.e., add, drop, exchange) and unit boundaries to ensure that the field station's records match the master NPAM database.
7) Train personnel involved in monitoring to be proficient in the survey technique and plant identification (see section 3.2 regarding annual monitoring workshops to assist field stations with some of the training requirements).
8) Enter monitoring data in the standardized database. Review data entered through the NPAM data entry interface for accuracy and fix identified errors. Adhere to data entry and submission guidance provided by the Project Coordinator.

1.2 GENERAL DESIGN | ADAPTIVE MANAGEMENT FRAMEWORK

The following subsections provide a short synopsis of the decision making framework and its constituent elements. This overview is not intended to be comprehensive; its aim is to provide the background needed to place the technical details of this document in an overall context. More thorough descriptions of the decision making framework are found in the project final report and in associated scientific publications.

1.2.1 GENERAL DESIGN | ADAPTIVE MANAGEMENT FRAMEWORK | Decision Structure

The conservation issue that NPAM addresses is the ongoing transition of native grass and forb covers into invasive grasses, principally smooth brome and Kentucky bluegrass, across Service-owned native prairies in the northern Great Plains. The purpose of NPAM is to provide annual decision guidance about defoliation actions at the management unit level for the goal of arresting and reversing this transition across the region. Under NPAM, it is recognized that efficient achievement of this goal is only as good as the understanding about how prairie systems respond to management actions; therefore, NPAM formally links decision making to monitoring to gain this knowledge and re-focus it towards future rounds of decision making.

NPAM can be viewed as a means of programming traditional defoliation actions through time in order to achieve a conservation objective. Selecting from a limited "menu" of traditional actions each year is an important feature of NPAM, because managers are familiar with the actions themselves (i.e., what the actions entail and what preparations must be made), and they know that actions that do not appear in the menu will not be recommended. A key advantage of a limited menu of actions is that it encourages participation by a larger number and broader diversity of cooperators.

For each management unit, NPAM makes use of current vegetation status of the unit and a set of predictive vegetation models to recommend a single management action to be taken each year. The management action menu contains only four options, but the options differ by grassland type (see complete description of management actions, also referred to as treatment alternatives, in section 1.1.4). In mixed-grass prairie, the potential management actions are *Rest*, *Graze*, *Burn*, and *Burn/Graze Combination*. In tallgrass prairie, the potential management actions are *Rest*, *Graze within Window*, *Burn within Window*, and *Defoliate*.

The conservation objective is based on a value that (1) rewards for increasing or maintaining amount of native prairie cover and (2) penalizes for using costly forms of management to do so. The objective is expressed in terms of a sum of these values over a very long time frame, which implies that today's decisions can be judged "good" or "poor" in part by their consequences farther into the future. Because of this long-range view of management, this objective has a clear conservation interpretation.

The connection between current vegetation condition, a management action, and an outcome is made through a predictive model of vegetation dynamics. The model is an essential part of the decision framework that permits comparison among different candidate actions and that allows the effect of any sequence of actions into the future to be evaluated. NPAM, however, acknowledges that uncertainty about behavior of the native prairie system makes the choice of an action difficult. Therefore, the NPAM design employs not a single model, but a *set* of models, each of which expresses a different scientific hypothesis about the system and makes a different prediction about response given a current vegetation condition and a single proposed action. Because a distinct prediction is made under each hypothesis, learning about each hypothesis is gathered over time by comparing realized management experiences to the outcomes that are predicted.

The potential to learn about management within this framework underscores the need for clear and consistent protocols for the execution of management actions and for the collection of monitoring data. Each management action on the menu must be well-defined and broadly understood so that it can be applied as consistently as possible over the network of cooperators: this consistency helps assure that predictions produced by the models are meaningful. Therefore, one goal of this protocol notebook is to provide a guide for uniform definition and application of treatments.

Monitoring and data recording serve four purposes in NPAM: (1) determination of current vegetation conditions for decision selection, (2) measurement of progress towards the management objective (i.e., production of native prairie cover), (3) assessment of the relative reliability of each predictive model, and (4) curation of a long-term data set for post hoc assessment and improvement of models. Because the utility of NPAM depends completely on the careful and consistent collection of data and their recording, this protocol notebook provides extensive detail on sampling setup, database preparation, field data collection, collection of treatment data, and data entry.

1.2.2 GENERAL DESIGN | ADAPTIVE MANAGEMENT FRAMEWORK | Institutional Learning

The learning that is accrued through the comparison of model predictions to realized outcomes is considered “technical learning”, because its focus is on the scientific uncertainty that hampers decision making. The entire decision making framework of NPAM is static, in the sense that while technical learning unfolds over time and management adapts in response to this learning, the action menu, the monitoring design, and the model set remain fixed into the indefinite future.

However, as experience with NPAM progresses, it may become apparent that some technical component is not working as expected, that some protocol is not as effective as thought, or that some aspect of project governance is problematic. In each of these circumstances, something is learned about the framework itself which may be of sufficient importance to revisit the affected elements of the framework. While technical learning is gained every year,

these episodes of “institutional” or “double-loop” learning are expected to occur less frequently, perhaps every 3-10 years.

Because institutional learning is important to the longevity and relevance of an adaptive management effort, the institutional structure of NPAM includes an Advisory Team. The charge of this team, which consists of the Project Coordinator, managers, biologists, and scientists, is to evaluate the project periodically, determine if the NPAM framework is performing satisfactorily, and recommend framework revisions or analytical work, as needed.

1.2.3 GENERAL DESIGN | ADAPTIVE MANAGEMENT FRAMEWORK | NPAM Database

A vital part of the NPAM decision framework is the database. The database was developed in 2010 as a stand-alone MS Access application, residing on each cooperator’s desktop computer. Extensive repairs and revisions were implemented to the Access database for the 2011 field season. After the 2011 field season, work began on a parallel application which permits web-based interaction with a central server; this centralized web-based database was completed in time for use in the 2012 field season. The advantages of this approach are that all maintenance operations can be performed on a single version of the database and that data entered from the field are captured at a central site instantly. The centralized database resides on the NPAM DOI SharePoint site. A separate User Guide describes in detail the appearance and operation of the centralized NPAM database (Appendix C).

2. SETUP ACTIVITIES

Preparing a management unit for inclusion in NPAM requires several setup steps. First, the unit must be mapped in GIS, and attributes about its physiography and management history must be recorded. Monitoring transects are then randomly generated and mapped. For each transect, one-time measurements of physical attributes are recorded. Finally, the NPAM database is populated with unit and transect information from ArcGIS.

2.1 SETUP ACTIVITIES | MANAGEMENT UNIT DESCRIPTION AND SHAPEFILE DEVELOPMENT

A cooperator nominates a unit for inclusion in NPAM by submtting ArcMap shapefiles and a background questionnaire. The Database Coordinator supplements the shapefile with physiographic information retrieved from other GIS sources.

2.1.1 SETUP ACTIVITIES | MANAGEMENT UNIT DESCRIPTION AND SHAPEFILE DEVELOPMENT | Entering a Management Unit in GIS

Requesting and Obtaining the Shapefile

Around January 1 of each year, the Database Coordinator will email the cooperators to request submission of new management units. When submitting a new unit, cooperators must provide the following ArcMap shapefiles to the Database Coordinator by February 15:

1) The digitized proposed management unit boundary. This can be submitted using the format from the Grassland Units feature class found in the FeaturesUnitsMonitoring geodatabase in RLGIS or similar structure.
2) The digitized native sod within the proposed management unit with wetlands, cropland, and tree plantings clipped out.
3) Belt transects developed during the initial Dakotas native prairie inventory (2007-2008), if applicable.

Processing the Shapefile

The Database Coordinator will process the submitted shapefiles as follows:
The shapefile is examined using the latest NAIP (National Agriculture Imagery Program) imagery to ensure that all lakes, semi-permanent wetlands, temporary and seasonal wetlands, and any other features such as tree plantings are clipped out of the native prairie boundary. The unit is then merged into the master management unit file where attributes are populated with the complex, organization code, and unit. The unit name is assigned by the cooperator when he/she submits the management unit questionnaire (see section 2.1.3) that must accompany each shapefile. The field calculator is used to populate the Unit Name field in the master table by using the expression: [Complex] +": " + [Org] +": " + [Unit]. After transects are generated (see section 2.2), they are populated in the same manner as the units with a slightly different expression.

The final shapefiles with the digitized management unit(s) and transect shapefile(s) will be returned to the cooperator for review by March 31.

Database Folder Structure [*for the Database Coordinator*]

- *Adaptive Management Database Transects* - Contains yearly archived transect shapefiles from the master database (e.g., 2010_transects_database.shp).
- *Adaptive Management Database Units* - Contains yearly archived management unit shapefiles from the master database (e.g., 2010_npam_units_database.shp).
- *Projects* - Contains yearly archived .mxd projects (e.g., 2010_napm_project.mxd)
- *Station-Level Folder (e.g., Huron WMD)*
  - *AM Native Sod* (subfolder) - Contains yearly archived spatial data for the native sod portions of the station units (e.g., 2010_hu_nativesod.shp).
  - *Station AM transects* (subfolder) - Contains yearly archived transects (e.g., 2010_hu_transects_final.shp)
  - *Generated AM extra transects* (subfolder) - Contains extra generated transects for stations to supplement replacement needs (e.g., 2010_hu_winter_transects_extra.shp)
  - *Generated transects ALL* (subfolder) – Contains raw generated transects (e.g., 2010_hu_winter_transects.shp)
  - *Management Unit Boundaries* (subfolder) – Contains station unit boundaries (e.g., 2010_hu_npam_units.shp)

2.1.2 SETUP ACTIVITIES | MANAGEMENT UNIT DESCRIPTION AND SHAPEFILE DEVELOPMENT | Measuring and Recording Management Unit Characteristics

Spatial characteristics of management units may assist in better understanding the dynamics of native prairie invasion. For the purposes of ad-hoc investigation (i.e., not part of the formal adaptive management framework), several environmental variables were identified and collected via GIS tools for each transect of management units added to the NPAM project in 2010. These variables are maintained within the NPAM database in a standalone table titled 'Environmental Variables'; they are not linked to the ArcGIS transect shapefile and therefore do not appear as attributes within the shapefile attribute table. The Database Coordinator and Project Coordinator will maintain these files in the central database. These spatial characteristics were not collected for NPAM management units or transects that were added after 2010. It is anticipated that these characteristics will be updated and obtained for all units before the ad-hoc analysis is completed.

Management Unit Characteristics

1) Precipitation data
   a. From two sources: Data Gateway and National Atlas
   b. Measurements represent average annual precipitation in inches.
   c. The years used to calculate the averages are as follows: Data Gateway (1971 – 2000) and National Atlas (1961 – 1990).

    d. The spatial resolution of the Data Gateway source and the National Atlas source is 4 km and 2.5 km, respectively.
2) Eco-Region
    a. Data come from National Atlas and consist of both Baileys and Omernik (Level IV).
3) Percent Grass on the landscape for management units within North and South Dakota and Eastern Montana
    a. Generated by FWS Region 6 Habitat and Population Evaluation Team (HAPET) office using 2003 Landcover data. Undisturbed Grass, a sub-category of the landcover, was based on both 2003 Landcover data and 2006 Conservation Reserve Program (CRP) data.
    b. "Grass" is anything that is not planted or cultivated (agriculture), intensely forested, or with intensely mechanized management.
    c. The size of the 'landscape' used to calculate percent Grass was a 32m x 32m area.
4) Ecological Site Name (Range Site)
    a. Data gathered from the Natural Resources Conservation Service (NRCS) Soils Data Mart.
5) Distance to Roads
    a. Road data were obtained from Earth Resources Observation and Science (EROS).
    b. The data were captured in 2009.
    c. Units of measurement are meters.
6) Distance to Crop, Hayland, and Undisturbed Grassland landcover types for management units within North and South Dakota and Eastern Montana
    a. Data are from 2003 Landcover generated from Region 6 HAPET office.
    b. Units of measurement are meters.
    c. A new landcover data set is currently in the process of development between Region 3 and 6 that will be more standardized across the project boundary and will be worth pursuing in future years when it becomes available.

2.1.3 SETUP ACTIVITIES | MANAGEMENT UNIT DESCRIPTION AND SHAPEFILE DEVELOPMENT | Management Unit Questionnaire

When a new management unit is proposed, cooperators must fill out a questionnaire specific to that unit that provides background necessary for participation in the NPAM project (Appendix D).

<u>Questionnaire Format and Method of Completion</u>
The questionnaire is a PDF document containing fields that cooperators complete with responses appropriate for each management unit. The completed questionnaire is sent, along with the required unit GIS shapefiles, to the Database Coordinator by February 15.

Questionnaire Questions

The questionnaire includes questions for the following type of information:

1) Station name, unit name, and station contact
2) Physical attributes:
    a. Area
    b. Soil type
    c. Physiographic region
    d. Grassland type
3) Estimate of current vegetation composition: native grasses and forbs, smooth brome, and Kentucky bluegrass
4) History
    a. Acquisition
    b. Use under previous ownership
    c. Past management – annual description of treatments for the previous seven management years (Sept 1 – Aug 31)
5) Management limitations

We rely on the cooperator's expertise and experience with the proposed site to address these questions. Soils information, physiographic region delineations, and grassland types can be obtained from GIS layers, and will be verified by the Database Coordinator.

Format and Location for Storage and Retrieval

The Database Coordinator will enter the questionnaire responses for each management unit into an Access database.

2.2 SETUP ACTIVITIES | GENERATING TRANSECTS

The Database Coordinator randomly generates transects for annual vegetation belt-transect monitoring for each management unit.

GIS Tool

2007 – 2010: Transects were originally generated in ArcView 3.3 with the use of a sampling tool developed by Tim Loesch of the Department of Natural Resource in Minnesota.
2011: Because the original sampling tool was not upgraded for use in ArcGIS, starting in 2011 transects are randomly generated in ArcGIS 9.3 using a script developed by Sean Fields (HAPET – Great Falls, MT).

Transect Dimensions

Transects are 25 meters long and 0.1 meter wide.

Transect Azimuth

When a transect is generated, the azimuth of the transect is calculated in GIS and stored as an attribute of the transect in the transect shapefile attribute table. The transect shapefile attribute table directly populates the transect table in the master Access database.

Density of Transects

For units containing more than 30 acres of native sod, transects are generated at a density of 1 per 5 acres. For units that contain less than 30 acres of native sod, transects are generated at a density of 1 per 3 or 4 acres. No unit will have fewer than four transects. Transects are located only within the native sod portion of the unit.

Minimum Spacing Between Transects

Transects are generated such that they are at least 65 meters apart from each other.

Buffering of Transects

Before generating the transects, the inside of the native sod boundary is buffered by 5 meters to reduce the risk of transects falling on fence lines, water edges, and planted shelterbelts. A 5-meter buffer is also used for features located within the management unit, such as fences, wetlands, and trees.

Surplus Transects

Surplus transects are generated using the same methods. These transects serve as replacement transects, if needed. The number of surplus transects that are generated depends on the unit, but is typically fewer than five.

Deadline for Generating Transects

Transects are generated and sent as shapefiles to cooperators via email by March 31.

Storage Scheme of Transects [*for the Database Coordinator*]

The transects generated for each management unit are stored within the station level folder as shown below.

Station-Level Folder (e.g., Huron WMD)

- *Station AM transects* (subfolder) – Contains yearly archived transects from the database (e.g., 2010_hu_transects_final.shp)
- *Generated AM extra transects* (subfolder) – Contains extra generated transects for stations with replacement needs (e.g., 2010_hu_winter_transects_extra.shp)
- *Generated transects ALL* (subfolder) – Contains all generated transects (e.g. 2010_hu_winter_transects.shp)

2.3 SETUP ACTIVITIES | TRANSECT CHARACTERISTICS

For each new transect created, one-time measurements of slope and aspect are collected and stored in the GIS database.

Field Data Collection – Slope and Aspect

When a new management unit and/or associated transect is added, cooperators will measure the slope and aspect of the vegetation monitoring site where each transect is located during the initial monitoring visit. The measurements are taken one time, upon first use of the transect; the measurements are not repeatedly taken each monitoring season.

Locating the Transect – Sub-meter accurate Trimble GPS units, or equivalent, are used to navigate to each transect. Users navigate to the *starting point* (i.e., the x1, y1 coordinate), toggle to the transect azimuth using the identifier tool, and lay out a 25-m tape. Some cooperators may choose to permanently mark the starting point (and possibly ending points) of the transects; in these cases, cooperators would mark the location with a permanent marker of their choice. Re-location of the transects each year is covered in section 3.3.1 under Locating and Setting Up Transects.

Method of Measurement – Slope and aspect are attributes that may differ at every point along a transect. The aim is to determine representative measures of these attributes from one or several points at the transect location. Slope is determined using a clinometer, measured in degrees (rather than percent slope). A flat site has 0 degrees of slope, while a vertical wall has 90 degrees of slope. Aspect is determined by compass direction (0-359 degrees, where North is 0 degrees) and is defined by the prevailing compass direction which the slope faces. For example, if you rode a sled down the slope, the compass direction you would travel is the aspect. Flat sites have no aspect.

Data Recording, Entry, and Storage – The Database Coordinator will provide an electronic spreadsheet to each cooperator that contains columns for management unit, transect number, azimuth, slope, and aspect. The management unit name, transect number, and azimuth columns will be populated, whereas the slope and aspect fields will be blank, indicating that these data need to be recorded. Cooperators record the slope and aspect on their monitoring datasheet, fill in the electronic spreadsheet with the recorded values, and email the completed spreadsheet back to the Database Coordinator. The Database Coordinator enters the slope and aspect data per transect in the attribute table of the transect shapefile contained in the master ArcGIS database. The transect shapefile attribute table directly populates the transect table in the master Access database.

2.4 SETUP ACTIVITIES | DATABASE POPULATION

The database in which the annual vegetation monitoring and management action data are entered contains a table that lists all the management units in the NPAM project and a table that lists all of the vegetation monitoring transects in the NPAM project. These tables are directly linked to and populated by the ArcGIS management unit shapefile attribute table (mgmt_unit.shp) and the ArcGIS transect shapefile attribute table (transects.shp). This information is stored an Access database maintained by the Database Coordinator and the Project Coordinator.

2.5 SETUP ACTIVITIES | PREPARATION/CONSIDERATION OF A MANAGEMENT UNIT FOR TREATMENT

Most preparations of an NPAM management unit for a management action are the same as those that a manager would conduct for any FWS unit. However, the annual timeline for the NPAM project means that more advanced planning may be necessary. For example, recommended management actions will be provided by September 1 of each year. If a cooperator wants to implement the recommended treatment that fall, most of the preparation will have to have already occurred. For treatment specific guidelines, see sections below.

Grazing

In general, grazing a unit will require a grazing cooperator[1], fencing, and a water source for the grazing animals. Water is often the limiting factor, although finding available grazing cooperators can also be a challenge. Good communication with the grazing cooperator will be important for NPAM units because treatment recommendations may change each year and because some of the treatments involving grazing have timing restrictions based on phenological sideboards (tallgrass units only). It will be up to the FWS manager to balance the commitment to following the NPAM recommendation and maintaining a working relationship with a grazing cooperator.

Burning

Being able to implement prescribed fire on NPAM units may require more advanced planning than other FWS units. A burn plan needs to be completed for any unit prior to burning. These can take 9-12 months, and therefore, for NPAM units it is recommended that these be completed prior to the first burn recommendation (i.e. as soon as the unit is enrolled in NPAM). In addition, FWS cooperators need to be sure that they have an annual smoke permit in place. The deadlines for this vary by state, but may need to be requested "just in case" because a fall burn may not be possible if the permit has not been requested earlier in the year. In addition to planning, adequate time must also be allowed for preparing the burn site (fire breaks, personnel, training, contacting neighbors, etc.). These tasks should be outlined in the burn plan. Communication and coordination with fire staff is critical to plan appropriately for a burn treatment.

Haying

Haying requires less preparation than the other treatments. However, identifying a haying cooperator and maintaining good communication is necessary.

[1] This is different than a NPAM "cooperator" who is a FWS employee; grazing "cooperators" are typically private ranchers.

3. RECURRENT ACTIVITIES

This section describes the series of recurring activities that take place each management year (1 Sep – 31 Aug) for each established management unit in NPAM.

3.1 RECURRENT ACTIVITIES | ANNUAL TIMELINE

For each established management unit in NPAM, a series of recurring activities takes place every management year (1 Sep – 31 Aug; Figure 1). Requests to add new units (including submitting a background questionnaire and the necessary GIS shapefiles) or make modifications to existing units are due by 15 February. The Database Coordinator will return unit and transect shapefiles to cooperators by 31 March. Required preparation activities, such as planning for treatment application occur at varying but specific times in the management cycle. The management action takes place at a time appropriate for the action. Annual vegetation monitoring workshops are held in early-mid June of each year. Vegetation monitoring may start in June and extend into August. Concurrently, the cooperator enters management and vegetation monitoring data in the NPAM database by 25 August. Finally, the Program and Database Coordinator close out the database and perform the analytical steps needed to provide management recommendations by 1 September for the next management cycle.

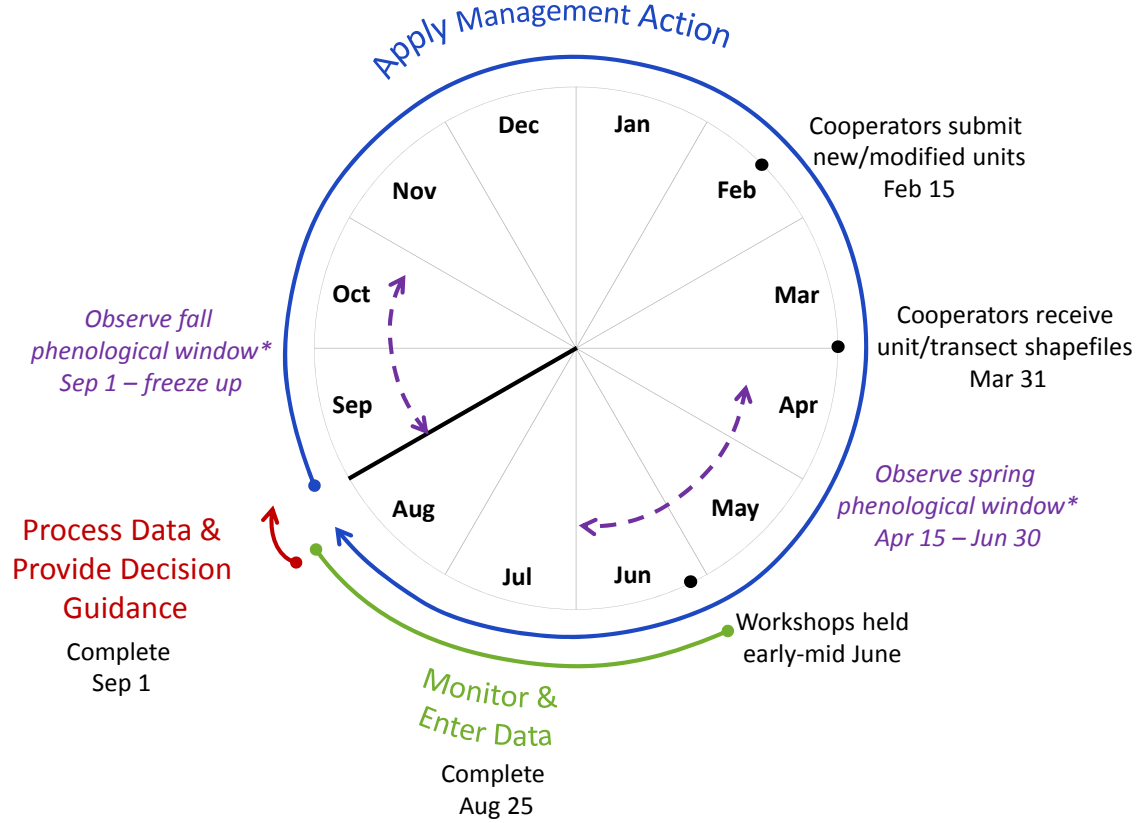

Figure 1: Recurring activities that take place each management year (1 Sep – 31 Aug). *Observing fall and spring phenological windows applies only to tallgrass cooperators.

3.2 RECURRENT ACTIVITIES | PLANNING ACTIVITIES

Before an NPAM treatment can be applied to a management unit in the current year, certain planning and preparation activities will likely be required. These activities may include the hiring and training of seasonal employees, securing permits, purchasing equipment or materials, and updating contracts. Vegetation monitoring relies on plant identification skills and familiarity with the methodology, therefore, monitoring training workshops are provided prior to the monitoring season.

Hiring

Cooperators often hire seasonal staff to assist with the completion of various inventories, monitoring, and other data gathering efforts that typically take place during the months of May – September (U.S. Fish and Wildlife Service seasonal employees are allowed to work up to 1039 hours in a calendar year). Seasonal employees will likely be hired to assist with following NPAM tasks:

1) Identify management windows
2) Collect belt transect data
3) Enter the data in the database and complete error checking
4) Manage any other logistics for the NPAM project

Cooperators are usually required to submit the estimated number of seasonal employees to their regional human resources office in November or December of each year. Advertisements for these positions usually open for application from early January through February 1. Cooperators should receive a hiring certificate sometime in March, and are able to pick from the individuals on that list. Hiring protocols sometimes change from year to year, so good communication with human resources will be important for the seasonal hiring process.

Cooperators may choose to hire seasonal staff through the Student Temporary Experience Program (STEP). This program allows cooperators to hire enrolled or accepted degree-seeking students taking at least half time credit at an accredited education institution. Hiring STEP students does not necessarily require the applicant to go through the competitive hiring process as described in the previous paragraph, so STEP can be a more streamlined process for the cooperator. More information on the STEP program can be obtained from the regional human resources office.

Training

Each year, two Field Activity Workshops will be held prior to collection of monitoring data. Workshops are usually held in early-mid June, depending on weather and plant phenology characteristics of the current year. This timing allows for sufficient plant growth for identification purposes, but also allows for adequate time following the workshop for cooperators to review materials and train additional technicians prior to monitoring work.

Workshops will be announced by the Project Coordinator in May, with each cooperator responding to the Project Coordinator (who will convey results to workshop hosts) with names

of attendees. One workshop will be held in North Dakota for cooperators in the mixed-grass region, and another workshop will be held in South Dakota or Minnesota for cooperators in the tallgrass region (although stations may attend either or both workshops). Workshops will generally be one day, allowing for travel time.

Workshops will focus on the tools and skills needed to execute monitoring activities for NPAM. Attendance by station lead/representative is required prior to the initial monitoring season (i.e., first year of participation in NPAM). Workshops are intended for attendance by station biologists, managers, and biological technicians. It is strongly encouraged that permanent staff (i.e., station biologists and managers) attend the workshops with their seasonal biological technicians, even if they have previously attended prior workshops. This is important for continuity, as well as for keeping plant identification skills fresh; even the most advanced persons can benefit from the annual workshops.

The workshops focus on six elements: 1) identification of plants groups used in the belt transect vegetation monitoring method from both the North Dakota and South Dakota Plant lists; 2) general plant identification, especially native and non-native grasses and grass-like plants; 3) belt transect methodology; 4) navigating to transects using sub-meter accuracy Trimble GPS units; 5) estimation of site slope and aspect; and 6) estimating fire effects and grazing utilization.

Recommended resources include the following plant identification guides:

1) Selected North Dakota and Minnesota Range Plants by Kevin K. Sedivec and William T. Barker (1998). Order through the NDSU Extension Service in Fargo, or available online at http://www.ag.ndsu.edu/pubs/ansci/range/eb69-1.htm
2) Grassland Plants of South Dakota and the Northern Great Plains by James R. Johnson and Gary E. Larson (1999). Order through South Dakota State University.
3) Wildflowers of the Northern Great Plains, Third Edition by F. R. Vance, J. R. Jowsey, J. S. McLean, and F. A. Switzer (1999). Order through University of Minnesota Press.
4) Prairie Grasses Identified and Described by Vegetative Characters by Jan Looman (1982). Out of print but available online at http://www1.foragebeef.ca/$foragebeef/frgebeef.nsf/all/aafc143

3.3 RECURRENT ACTIVITIES | MONITORING

This section consists of three subsections. The first two subsections describe the annual vegetation monitoring and annual recording of management action treatments that occur each management year (1 Sep – 31 Aug) for every management unit in the NPAM project. The third subsection describes monitoring and recording of dates in the fall and spring of each management year when specific stages of phenology are reached; this monitoring pertains solely to stations with tallgrass units in NPAM.

3.3.1 RECURRENT ACTIVITIES | MONITORING | Vegetation

Vegetation monitoring is completed during June through August, regardless of management treatment. Vegetation monitoring utilizes the Belt Transect Method (Grant et al 2004; Appendix E).

Equipment Needed

1) Metric 30-m tapes indexed at 0.5-m increments (at least 2 per crew) available at Forestry Suppliers (item no. 39943)
2) Suunto Navigator compass MC2D/MM Azimuth (0-360°) available at Forestry Suppliers – several models. Clinometers are also useful and available (item no. 43830)
3) Hand lens/magnifier – many models valuable at Forestry Suppliers
4) Sub-meter accurate GPS Unit (e.g., Trimble XT)
5) Clipboards
6) Data sheets (printed on Write-in-the-Rain paper (in case of precipitation during sampling)
7) 1-m electric fence post with triangular head

Plant Lists

We classify vegetation according to a moderately detailed, hierarchical breakdown of plant groups (Appendices E and F). We confine native herbaceous types to categories of moderate rather than fine detail because (1) subtle shifts in species makeup among native grass-forb types occur continually due to precipitation patterns, (2) sampling efficiency and accuracy among investigators are compromised by increasing the complexity of classifications, and (3) restoration work is mainly concerned with relatively few species of noxious, exotic, and otherwise invasive plants that compromise the integrity of prairies. We also include commonly occurring associations of intermingled native and exotic vegetation, as well as woody types encountered (Appendix F). North Dakota and South Dakota lists are the same when categories are collapsed into similar, general categories (Appendix G). South Dakota cooperators use the South Dakota plant list. All other cooperators use the North Dakota plant list.

Transect Configuration

Transects are 25 m in length, the number and location of transects having been previously determined and provided to each cooperator (see section 2.2).

Locating and Setting Up Transects

Sub-meter accurate GPS units (e.g., Trimble XT) are used to navigate to each transect. If transects have been permanently marked, users navigate to the *starting point* (i.e., the x1, y1 coordinate), toggle to the transect azimuth using the identifier tool, locate markers and lay out the 25-m tape. Most cooperators will not have permanently marked transects. In these cases, navigate to the *starting point* (i.e., the x1, y1 coordinate) of the transect using the GPS unit (hint: create labels for GPS transects where the marker is placed at the starting point of each transect). Toggle to the transect azimuth using the identifier tool. Once at the starting point,

affix a 1-m tall stake, attach the tape, and walk out the tape while following the GPS receiver to the end of the 25 meters.

One-Time Transect Characteristics

The first time a transect is located, slope and aspect for the transect will be measured, recorded, and relayed to the Database Coordinator. The protocol for taking these transect-level measurements is described above in section 2.3. Methods used to collect these data will be reviewed at the annual training workshops.

Timing of Monitoring

Plant identification is facilitated when completed during middle June through August when both cool- (C3) and warm-season (C4) plants are more easily recognized. Care should be taken in units treated with grazing, because late-season monitoring may be hindered by removal of significant plant material necessary for identification of plant groups. Monitoring should be timed to occur when plants are recognizable (i.e., between grazing periods in a twice-over system). In units treated with prescribed fire, monitoring may need to be deferred until towards the end of the monitoring period to allow for sufficient plant growth necessary for identification of plant groups. However, monitoring is required for all units in all years, regardless of treatments used.

Data Collection Protocol

Stretch the measuring tape across the vegetation (as above). The transect consists of 50 0.5-m x 0.1-m segments. Use canopy cover for ocular estimates to decide the dominant plant group in each segment, based on either ND or SD Plant Lists (Appendix F). In practice, the investigator holds the tape loosely about 1 m above ground and walks steadily along it while looking down and classifying the dominant plant group in each segment (imagine each 0.5 x 0.1 meter belt segment as if it were a quadrat). In most cases, the classification is simple because only one plant group dominates cover. In many cases however, percent cover may be similar between two or three coexisting groups and classification becomes more difficult. In all cases, record the dominant plant group. Use canopy cover when determining the dominant plant group (note that understory/remainder class is used for low shrub types in North Dakota list). The process is rapid because classes of vegetation often are similar among successive segments; the investigator must only note points on the meter tape at which the vegetation class changes, and the nature of the change. Data are recorded by an assistant on standardized paper field forms (Appendix H). Initially, investigators may be slow to identify plant groups, but with practice and familiarity can classify vegetation as quickly as they can walk along the tape and communicate data to an assistant (e.g., with practice a 25-m transect requires only a few minutes to complete). Trained observers with moderate experience should be able to complete (on average) 30 transects/day, allowing for 6-8 hours of monitoring time. Be certain that all transects are completed within a unit. Larger units will require multiple days to complete. Field forms are to be photocopied at the end of each day and copies stored off-site in case of fire or other data loss of primary files.

Flooded Transects – If the observer cannot access a transect to conduct monitoring due to flooding, the observer should record all stops along the transect as '-9' to indicate that no data were collected for the transect. If the transect is accessible, but is completely or partially under water, the observer should use the following guidance:

- If the transect is only recently and shallowly flooded, such that the observer can identify the dominant plant association per stop along the transect, the observer may use the appropriate code for the dominant vegetation.
- If the transect has been flooded for some time or the flooding is extensive enough such that the observer cannot identify the dominant plant association, the observer should use the code for wetland vegetation/open water.

In all cases, the observer should note the extent of flooding on the datasheet and in the database upon data entry.

It is natural for wetlands to expand and contract with weather conditions, such that a stop along a transect may have a prairie vegetation code in one year, but a wetland code in another year. If, however, a transect is dominated by the wetland vegetation/open water code for consecutive years, this transect should be replaced with an appropriately placed upland transect. The Database Coordinator will periodically review transects for such instances and take necessary measures if warranted. If the cooperator thinks that a transect should be replaced due to repeated flooding during the monitoring season, and the Database Coordinator has not already identified the problem, the cooperator should take action and notify the Database Coordinator of the situation.

3.3.2 RECURRENT ACTIVITIES | MONITORING | Management Actions

In addition to recording and monitoring vegetation, cooperators also need to monitor and record specific information about the management treatments that are applied to their NPAM unit(s) every year. For grazing and burning, a field visit will be necessary to gather the required treatment monitoring information. All of the necessary treatment monitoring information needs to be entered into the NPAM database and submitted with the vegetation data. A field datasheet for collecting and recording the management action related information is provided in Appendix I.

<u>All Management Actions</u>
The NPAM project requires that the following information be filled in the database for every type of management action that is carried out:

1) Management Unit Contact: typically the manager or biologist
2) NPAM Unit where the management action occurred
3) Management Year (September 1 to August 31)
4) Start date and End date: Enter the date that the management action started (e.g., the date that grazing animals were put on a unit) and the date that the management action ended (e.g., the date that the grazing animals were removed from a unit).

5) Native prairie upland treated: Include acres of native prairie within the NPAM unit that were treated with the particular management action; for example, the acres of the unit that were accessible to grazing animals, or burned, or hayed. In most cases the treated acres will be the same as the acres of native sod uplands on the NPAM unit, which the database automatically populates for reference.

Graze

In addition to the information previously noted, the NPAM project requires that the following information be recorded and entered in the database for every grazing treatment:

1) The number of animals used for the grazing treatment
2) The appropriate grazing animal from the drop down list in the database. If more than one type of animal was used, for example cows and bulls, choose the option for "multiple classes of animal" and specify the animal types in the comments section.
3) Stocking rate, measured in Animal Unit Months (AUMs) per acre.
4) The category for grass utilization. This must be based on a field visit that occurs no later than two weeks after the grazing animals are removed from the unit. Please refer to the detailed guidance on estimating grass utilization below.
5) Phenological Stage *[tallgrass units only]*: In addition to the dates that the grazing animals were put on the unit and removed from the unit, on tallgrass units, cooperators must record the phenological stage of the unit on both the start and end date of the grazing period. See the subsection 'Phenological Stage' (below) for necessary details on collecting and recording these data.

Estimating Grass Utilization – Grass utilization is a critical piece of information which cannot be adequately captured by estimates of AUMs alone. To get an estimate of Grass Utilization, visit each of your grazed NPAM units **within 2 weeks of removing the livestock from the unit** to obtain an ocular estimate of grass utilization using the photographic guides attached (SDSU; Appendix J).

Although it will require an individual to be on site to make an accurate determination, this will be a simple task that can be performed by anyone on the permanent or seasonal staff. Grass utilization estimates are an average for the entire NPAM unit based on a walk-about of the unit. Utilization will get binned into 1 of 6 different rating classes:

1) Unused (0%)
2) Slight (1 to 20%)
3) Moderate (21 to 40%)
4) Full (41 to 60%)
5) Close (61 to 80%)
6) Severe (81 to 100%)

Key points to keep in mind when estimating grass utilization using the SDSU photographic guides:

1) Photographs in the grass utilization guide (pages 10 through 17) show six levels of use for eight species common to South Dakota ranges and cultivated pastures. Plants have

been clipped to show utilization of 0% (unused), 10%, 30%, 50%, 70%, and 90%. These use levels are designed to aid in placing utilization estimates in a specific use rating class. Determining the use rating is quite easy and fast for individual plants or areas in a pasture. The grazed plant(s) is compared to the photographs of that species which show various levels of use. The best fit between the grazed plant and the photographs allows direct placement into one of the use ratings described. Utilization estimates for individual plants are averaged or expanded to represent use of the area. The photographs on pages 18 through 28 provide for comparative evaluation of degree of use for different range sites and cultivated pastures in several parts of South Dakota.

2) It is important to remember that utilization refers to percent of weight removed, not to percent of height removed. Plant height of a grass will vary greatly from year to year or from location to location, but weight distribution from bottom to top of a grass is consistent. Most of the weight of a grass plant is concentrated nearer the bottom.
3) The complexity of grass utilization patterns in many situations dictates a need to simplify procedures for utilization estimates. This is accomplished by selecting key grasses (indicator grasses) in key areas for utilization estimates rather than by estimating utilization for all species. A species selected as key should be one of the most abundant species in the unit during the season of livestock use, and make up a large portion, even the major portion, of the animal's diet. There is no need to do any of the following:
    (1) Estimate utilization at each transect
    (2) Use the Paced Transect Method described on Page 7 [of the grass utilization guide]
    (3) Make a Pasture Use Map described on Pages 6 and 7 [of the grass utilization guide]
    (4) Use the Dot-Dash Tally Form (Figure 5 on Page 8 of the grass utilization guide).
4) Analogous to the key plant concept for determining utilization is the key area theory. Just as a single species or group of species is a key to correct use, so is a representative area to estimate utilization. The principle is that no pasture of appreciable size or complexity is used uniformly. The intermediate areas (between the overused and under-used areas) are the key areas from which to judge utilization of the pasture.
5) For pastures grazed once, but briefly, estimate utilization as close to the livestock removal dates as possible. This is especially important, because grass continues to grow and the longer the delay in estimating utilization, the more distorted and misleading estimates of use will be.

<u>Burn</u>

In addition to the information previously noted, the NPAM project requires that the following information be recorded and entered in the database for every burn treatment:

1) Fire Type: either prescribed or wildland
2) Burn Intensity: Choose the appropriate class from the dropdown menu. The burn intensity is affected by the firing techniques (e.g., backing fire, head fire), firing pattern,

vegetation dryness or green-up, and weather conditions during the burn. A complete description is found in the table below:

	Substrate	Vegetation
Unburned	not burned	not burned
Scorched	litter partially blackened; duff nearly unchanged; leaf structures unchanged	foliage scorched
Lightly burned	litter charred to partially consumed, but some plant parts are still discernible; charring may extend slightly into soil surface, but soil is not visibly altered; surface appears black (this soon becomes inconspicuous); burns may be spotty to uniform depending on the grass continuity	grasses with about two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable
Moderately burned	leaf litter consumed, leaving coarse, light gray or white colored ash immediately after the burn; ash soon disappears leaving bare mineral soil; charring may extend slightly into soil surface	unburned grass stubble usually less than two inches tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning; burns tend to be uniform
Heavily burned	leaf litter completely consumed, leaving a fluffy fine white ash, this soon disappears leaving bare mineral soil; charring extends to a depth of 1 cm (0.5 in) into the soil; this severity class is usually limited to situations where heavy fuel load on mesic sites has burned under dry conditions and low wind	no unburned grasses above the root crown; for other species, all plant parts consumed leaving some or no major stems or trunks, any left are deeply charred; this severity class is uncommon due to the short burnout time of grasses
Not applicable	inorganic preborn;	none present preborn;

3) Fire Coverage: Fire coverage is the percent of the total native prairie uplands on the management unit that burned. That is, the entire native sod area could have been treated with a burn, however the fire may have carried in a patchy manner such that less than 100% of the area actually burned. Select the appropriate percent of the treated area that burned from the drop-down menu; options are in 10 percent increments.
4) Phenological Stage [*tallgrass units only*]: In addition to the date of the burn, on tallgrass units, cooperators must record the phenological stage of the unit on the date of the burn. See the subsection 'Phenological Stage' (below) for necessary details on collecting and recording these phenological data.

<u>Hay [*tallgrass units only*]</u>

In addition to the information previously noted, the NPAM project requires that the following information be recorded and entered in the database for every hay treatment:

1) Whether a rake was used to remove litter after the haying treatment
2) The approximate stubble height in inches

Non-NPAM Treatments

There are times when non-NPAM treatments are needed to address issues within a NPAM unit; for example, spot herbicide treatment to control woody vegetation or mowing to control sweet clover. Whatever the treatment, it should be documented in the NPAM database. The following information is required for non-NPAM "special" treatments:

1) Start date and End date: Enter the dates that the special treatment began and ended just for the specific NPAM unit
2) Native sod upland treated: Include acres of native sod within the NPAM unit that were treated
3) Comments: Describe the type of treatment and brief description of details

Phenological Stage of Management Unit [*Tallgrass units only*]

In addition to the information outlined above, when a graze or burn is carried out on a tallgrass unit, cooperators must record the phenological stage of the unit on both the start and end date of the treatment. For prescribed fires, the start and end date will likely be the same day and thus the same phenology. However, because grazes span a period of time, the start and end dates will have different phenology; it is very important that the phenology be observed and recorded on both the day that the grazing animals are put on the unit and the day that the grazing animals are removed from the unit. When recording the phenology on the day that the grazing animals are removed from the unit, the observation should be made at a reference site; that is, an untreated location adjacent to the grazed unit (e.g., a fence line or an adjacent unit that was not treated). The chosen reference site should have the same phenology at the treated management unit at the beginning of the grazing event. A separate Phenology User Guide that includes all relevant information, including visual guides and field datasheets, was developed and is included in the Appendix (Appendix K). A condensed version of the information is included here for completeness of the protocol notebook.

The phenology that is observed and recorded depends on the season of the treatment, as detailed below.

Fall Treatment – If it is a fall treatment (applied between September 1 and December 31), record phenology as follows:

Record the phenology of the dominant warm-season native grasses and cool-season invasive grasses (both smooth brome and Kentucky bluegrass) on the unit. Record whether the majority (>50%) of the warm-season native grasses on the unit are active or have gone to seed, and whether >25% of smooth brome and Kentucky bluegrass on the unit are fall green-up plants (i.e., plants with new fall tiller growth after the summer dormant period) or whether >75% of smooth brome and Kentucky bluegrass on the unit have gone dormant for the season (which usually occurs with the first killing frost of the season). This information will allow you to classify the unit into one of three phenological stages in the database.

1) >50% of warm-season native grasses are still active

2) >50% of warm-season native grasses have gone to seed and >25% of cool-season invasive grasses are fall green-up plants
3) >50% of warm-season native grasses have gone to seed and >75% of cool-season invasive grass have completely senesced

Spring Treatment – If it is a spring treatment (applied between January 1 – August 31), record phenology as follows:

Record the phenology of smooth brome on the unit. Record whether the majority (>50%) of smooth brome on the unit has fewer than 5 leaves or has at least 5 leaves, and record whether the majority (>50%) of smooth brome on the unit is before, during, or after inflorescence. This information will allow you to classify the unit into one of three phenological stages in the database.

1) >50% of smooth brome plants on the unit have fewer than 5 leaves
2) >50% of smooth brome plants on the unit have at least 5 leaves, but inflorescences are not yet visible
3) >50% of smooth brome plants on the unit have visible inflorescences or have already passed inflorescence

Field datasheets for collecting and recording the phenological stage associated with the graze and burn management actions are provided as an appendix within the Phenology User Guide (Appendix K).

3.3.3 RECURRENT ACTIVITIES | MONITORING | Station-Level Phenology

Stations with units classified as tallgrass prairie are asked to observe the phenological stage of the prairies in their locale to determine the dates when specific phenological stages are reached. These data must be collected each fall and spring and are used to classify the timing of tallgrass management actions relative to the cool-season windows (as defined in section 1.1.3). The variation in timing of phenological stages across locations and years necessitates that these data be collected per station and per year. A separate Phenology User Guide that includes all relevant information, including visual guides and datasheets, was developed and is included in the Appendix (Appendix K). A condensed version of the information is included here for completeness of the protocol notebook.

Location of Observation

Cooperators are asked to select a site in their area that is native sod and that has not received a defoliation treatment in the current growing season. Cooperators are not expected to visit each NPAM management unit to collect these data, but instead to select a site that is accessible and easily incorporated into a daily routine (e.g., a site that is near the field station). Some additional considerations for identifying a site to collect station-level phenological data can be found in the Phenology User Guide (Appendix K).

Protocol for Observation

To make the phenological observations, walk through the chosen site every 2-4 days during the fall observation period (approximately September 1 until freeze-up) and during the spring observation period (approximately April 15 through June 30). Go to five different areas within the selected site. When choosing the five areas, account for any natural variation at the site that could influence phenology (e.g., soil moisture, slope). At each of these five areas, imagine a 1-meter square quadrat and make an ocular estimate of the percent of the area that has reached the phenological cues of interest (as described below). Record the data on the Station-level Phenology Data worksheets found as appendices within the Phenology User Guide (Appendix K) and fax or email it to the Project Coordinator by July 15 of each management year.

Fall Phenology

During the fall observation period (September 1 through freeze-up), cooperators are asked to observe the phenology of the dominant warm-season native grass species and cool-season invasive grass species (smooth brome and Kentucky bluegrass) at the site and to make an ocular estimate at each stop of the following:

1) The percent of warm-season native grass plants in the 1-m^2 plot that has gone to seed.
2) The percent of cool-season invasive grasses in the 1-m^2 plot that is fall green-up plants.
3) The percent of cool-season invasive grasses in the 1-m^2 plot that is completely senesced (i.e., brown in color).

Spring Phenology

During the spring observation period (April 15 through June 30), cooperators are asked to observe the phenology of smooth brome at the site and to make an ocular estimate at each stop of the following:

1) The percent of smooth brome in the 1-m^2 plot that has at least 5 leaves.
2) The percent of smooth brome in the 1-m^2 plot that has developed an inflorescence.

3.4 RECURRENT ACTIVITIES | DATA ENTRY AND CHECKING

Cooperators enter vegetation monitoring data and management action data in July and August of each year, prior to an August 25 deadline. Data are entered into the NPAM database through a web-based portal hosted on the DOI SharePoint website. A central copy of the database, hosted on a server, is maintained by the Database Coordinator. As cooperators enter data or as they edit stored data, the data elements are captured instantaneously in the central database. The Database Coordinator assists cooperators with website login issues and with use of the data entry portal.

A Database User Guide (Appendix C) describes the input screens, data fields, navigational methods, and simple queries for quality checking. Data quality is maintained through restricted data fields and validation/consistency checks. However, some errors cannot be caught by the database (e.g., incorrectly entered plant codes, management dates, or AUMs); therefore, cooperators are expected to thoroughly review all of their entered data for errors. After

cooperators have entered and reviewed their data, the Database Coordinator and Project Coordinator should perform the following checks prior to processing the data for decision selection:

1) Confirm that each management unit in the database has management action data entered, and confirm that management actions that are entered are matched to a management unit record.
2) Confirm that each transect in the database has vegetation monitoring data entered, and confirm that all vegetation monitoring data are matched to a transect record.
3) Confirm that the cooperator responds to the "recommended actions" question if a treatment was assigned in the previous year.

3.4.1 RECURRENT ACTIVITIES | DATA ENTRY AND CHECKING |Data Summaries

Summaries of the vegetation data are available through the NPAM database via built-in Excel queries (see Database User Guide; Appendix C). Six summaries, all at the level of the management unit, are available and include: 1) life form, 2) degree of invasion, 3) grass forb composition, 4) low shrub composition, 5) understory composition of low shrub community, and 6) weedy forb composition. If desired, cooperators run these summaries themselves.

3.5 RECURRENT ACTIVITIES | DATABASE CLOSE-OUT AND PROCESSING

At the close of the data entry period (August 25), the Project Coordinator processes the data in order to perform model weight updating and selection of optimal management actions for the new management year. Annual database close-out includes performing data quality checks (see above) and resolving data entry issues with cooperators, as needed. When the last issues are resolved, the Project Coordinator runs an automated process that establishes a link between an Access database (Coordinator Database) and the centralized SharePoint database (Cooperator Database) and downloads the cooperators' data into the Coordinator Database. After download of the data to the Coordinator Database, the Project Coordinator follows several processing steps.

<u>Processing Steps</u>

The Coordinator Database is designed such that that the Project Coordinator follows a set of automated sequential steps to process the data. The processing steps are outlined in an official user guide for the Coordinator Database; the user guide is held by the Project Coordinator and is not included as part of the Protocol Notebook. The processing steps are outlined in general below:

1) Use a set of rules to flag questionable management records for review by the Project Coordinator;
2) Assign each unit to an NPAM management action based on a rule set that interprets the management data;

3) Assign each unit into a current defoliation and vegetation state based on rule sets applied to the management and vegetation monitoring data;
4) Perform updating of model belief weights (see below);
5) Identify an optimal management action for each unit based on current states, updated model belief weights, and updated policies (see below);
6) Prepare reports for cooperators, including management recommendations and unit-level summaries (see below)
7) Prepare project-level summaries (see below).

Model Weight Updating

The process of model weight updating is carried out as one of the processing steps carried out by the Project Coordinator (see Step 4 above). The Coordinator Database contains a table of model weights for each grass type. In each table is a single record per management year containing a set of weights (values between 0 and 1) on each of the predictive models for the grass type. The goal of the model weight updating step is to update the values from the previous management year with new ones that reflect revised credibility of each model based on how well each one predicted current-year management outcomes. The updated values are appended to the model weight table as the new current model weights for the given management year.

Model weight updating is performed by a SAS program that is external to the Coordinator Database. As part of the previous processing steps, the Coordinator Database generates the following data summaries which are used as input to the SAS program: (1) the table of current model weights, (2) tables of summarized vegetation monitoring data for the prior and current years (transect-level totals of number of stops with native prairie, smooth brome, Kentucky bluegrass, and remainder-dominated types), (3) a table of current-year executed treatments, and (4) a table of defoliation histories, by management unit. The SAS program processes these input files and produces an Access table that includes the updated model weights as output. The outputted Access table is then uploaded to the Coordinator Database, at which time the Project Coordinator can continue with the remaining processing steps.

Identification and Distribution of Recommended Management Action

After updating the model weight table, the Project Coordinator uses the Coordinator Database to generate optimal management recommendations for each unit for the new management year. For each unit, the database automatically gathers the following information: (1) its grassland type, (2) its management action restriction class (unrestricted, unable to graze, unable to burn), (3) its 7-year defoliation history, and (4) its current vegetation composition state (percentage cover in native prairie, smooth brome, Kentucky bluegrass, and remainder). Based on this gathered information and the updated model weights, the database then automatically looks up the optimal recommended action for the unit in the coming year. The list of actions is stored in the database for use in the next monitoring cycle as part of the "recommended actions" portion of the database.

Cooperator Reports

The Coordinator Database exports two reports that are formatted for distribution to cooperators by the Project Coordinator by September 1 of each year. The first report identifies the selected recommended actions for each unit. The second report details the state of each management unit, along with the management action implemented, per management year from the time the unit became enrolled in NPAM to the present management year.

NPAM Data Summaries

In addition to the reports created by the Coordinator Database, the Project Coordinator has the option to generate various summaries of the NPAM data[2] that may be of interest. Summaries are available for both vegetation data and management data. For vegetation data, the coordinator makes selections regarding the management year, plant code (all codes, 10 codes, 2 codes), and spatial-level (entire NPAM region or by state) of interest when creating summaries. The summary for management data includes the comparison of the recommended management actions with the implemented management actions; for this summary, the coordinator makes a selection regarding the management year and grass type of interest. These vegetation summaries may be of interest to cooperators as well as Regional Office staff, and will be shared by the Project Coordinator as seen fit. The management summary is relevant for estimating partial controllability, an important component of the NPAM decision framework and optimization.

3.6 RECURRENT ACTIVITIES | CARRY OUT MANAGEMENT ACTION

The final recurrent activity that carries the NPAM process forward into the next management year is the execution of a management action. The expectation of the program is that cooperators will carry out the recommended action provided by the Program Coordinator, because this action is the optimal one that accounts for the current status of the management unit, how the unit is expected to respond to the action, and how that response contributes to learning about the native prairie system. Given this guidance, the cooperator then chooses and implements one of the NPAM actions (see section 1.1.4).

An action other than the recommended action may be selected by the cooperator, either by choice or by necessity. The NPAM framework accounts for the fact that actions will not always be carried out as planned, but it cannot anticipate specific events that may disrupt or impede the application of a specific planned management action. Therefore, the cooperator has the flexibility of applying a non-recommended action if circumstances warrant it. In any case, the cooperator keeps detailed information about the action implemented for later data entry.

[2] These are project-level summaries, as opposed to the unit-level summaries that cooperators can generate for themselves as part of the centralized Cooperator Database (see section 3.4.1).

During the process of entering data in the NPAM database, the cooperator indicates whether or not the recommended management action was implemented, in the cooperator's judgment, in the current year. If the recommended action was not implemented, the cooperator is prompted to provide a reason as to why it was not followed. The purpose of this information is to provide more reliable assessments of how often recommendations are followed and to suggest refinements to the predictive models that may more fully account for these circumstances.

3.7 RECURRENT ACTIVITIES | UPKEEP OF PROTOCOL NOTEBOOK

The purpose of the protocol notebook is to provide operational guidance to the cooperating land managers and the project and database coordinators. The notebook is intended to be a living document; to remain relevant as guidance, it should be periodically revised as components of NPAM change. Maintenance of the notebook is the responsibility of the NPAM Advisory Team. It is recommended that review of the notebook be a standing item on the Advisory Team's annual meeting agenda. Identification of necessary updates, as well as assignment of responsibility for making said updates resides with the Advisory Team. The project record (Appendix A) requires update on an annual basis. The Project Coordinator shall be responsible for updating the project record.

Updated versions of the protocol notebook will be identified by the date of the revision; this date will appear in three places: 1) the title page; 2) the second page under "Versions"; and 3) the footer of the notebook. When a revision is made, the Database Coordinator will post the updated version of the notebook to the NPAM DOI SharePoint website; at the time of the posting, the Database Coordinator will notify cooperators, via email, of the newly revised Protocol Notebook.

LITERATURE CITED

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Washington DC: Adaptive Management Working Group, U.S. Department of the Interior. Available: http://www.doi.gov/initiatives/AdaptiveManagement/index.html (September 2011).

Willson, G. D., and J. Stubbendieck. 2000. A provisional model for smooth brome management in degraded tallgrass prairie. Ecological Restoration 18:34-38.

Below is a brief project record detailing some important events leading up to the beginning of NPAM, and some major events and milestones during the first four years of NPAM.

Background (pre-NPAM)

- Work by Todd Grant, Bob Murphy, and Karen Smith at refuges in northern North Dakota in the 1990s and early 2000s.
- In 2004, Region 6 formed the Grassland Monitoring Team; Todd Grant and Bridgette Flanders-Wanner were a part of this team.
- In 2004, a meeting of Region 6 refuge staff in Minot, ND was held at which Terry Shaffer gave a presentation on adaptive management. The presentation stimulated interest by Regional Office staff, particularly the Chief of Refuges, Rick Coleman.
- Publication of the following paper: Murphy, R. K., and T. A. Grant. 2005. Land management history and floristics in mixed-grass prairie, North Dakota, USA. Natural Areas Journal 25:359–368.
- Brome Summit, March 2006, Jamestown, ND
    - http://www.npwrc.usgs.gov/pdf/npwrc1629.pdf
    - Attendance by Region 6 and Region 3
- Dakotas-MT Prairie Inventory, 2006-2008
- Minnesota
    - Grassland Monitoring Program, 2007- ongoing
    - Adaptive Management Consultancy – MN Grasslands (Workshop December 2007, Morris, MN)
- Publication of Grant et al. (2009) "An emerging crisis across northern prairie refuges: prevalence of invasive plants and a plan for adaptive management" in *Ecological Restoration*

NPAM

2008

- NPAM funding through the Refuge Cooperative Research Program (RCRP)
    - RCRP is a program that funds management/research partnerships between USFWS and USGS
    - The RCRP goal is to facilitate science-based management on USFWS National Wildlife Refuges
    - The RCRP focus is multi-refuge, multi-region problems and the implementation of adaptive management
- Organization of the core NPAM development team
    - Terry Shaffer and Clint Moore, USGS co-PIs
    - Jill Gannon, USGS post-doc
    - USFWS Science Team
        - Kim Bousquet, Pauline Drobney, Vanessa Fields, Bridgette Flanders-Wanner, Todd Grant, Sara Vacek
- Solicitation of USFWS Refuge cooperator interest throughout the Prairie Pothole Region of USFWS Regions 3 and 6.

- NPAM Kick-Off Meeting, 1st annual cooperator meeting, Jamestown ND (July 2008)
    - Interactive meeting where we defined the problem, area of focus, management objective, management alternatives, management cycle, management constraints, and central uncertainties

2009

- Cooperator interest survey and nomination of management units to participate in NPAM
- Justin Dupey, Huron Wetland Management District, joins the core team and provides GIS and database support
- Pilot season
    - Management actions selected as per convention
    - Belt-transect vegetation monitoring
- Kevin McAbee, USFWS, collaborates with the core team for a term of service to develop the NPAM database
- 2nd annual cooperator meeting, Jamestown ND (October 2009)
    - Discussion of the pilot season
    - Demonstration of a first draft of the NPAM Database
    - Demonstration of a first draft of the decision framework models
    - Solicitation of cooperator feedback

2010

- Cooperators enroll 120 management units
    - 81 mixed-grass units, 39 tallgrass units
- Completion of the NPAM Database by Kevin McAbee, with support by Todd Sutherland
- Pre-adaptive season
    - Management actions selected as per convention
    - Belt-transect vegetation monitoring
- Completion of the provisional adaptive management decision framework
- Cooperators enter management and vegetation data into the NPAM Database for the 2009 and 2010 management years.
- First round of management guidance; management actions for the 2011 management year were recommended to cooperators on August 31, 2010
    - Recommendations were based on the provisional decision framework and the current state of each management unit (observed via 2010 monitoring)
        - Alternative models were equally weighted

2011

- 3rd annual cooperator meeting, Jamestown ND (February 2011)
    - Review of the 2009 and 2010 vegetation and management data, cooperator feedback survey, 3-yr plan, accomplishments to date, what remains to be completed, components of the provisional decision framework, and existing and future modifications to framework elements

    - Solicitation of cooperator feedback
- Bridgette Flanders-Wanner, Huron WMD Wildlife Biologist and core team member, takes a new position in Region 1 and steps down from the core team
- Cami Dixon, Chase Lake Wildlife Biologist, takes a new position as Region 6 Dakota Zone Biologist and joins the core team as the NPAM Project Coordinator
- Jennifer Zorn, I&M GIS Database Manager, joins the core team as the NPAM Database Coordinator
- Review and revision of the elements of the provisional decision framework (first instance of 'double-loop learning')
- Contract with Lincoln Park Zoo (Eric Lonsdorf, Sarah Jacobi, Victoria Hunt) to improve the existing NPAM Access Database and to develop a centralized web-version of the database
- Cooperators enroll 122 management units
    - 84 mixed-grass units, 38 tallgrass units
- First adaptive season
    - Management actions selected taking the 2011 recommended management actions into consideration
    - Belt-transect vegetation monitoring
- Completion of the updated adaptive management decision framework
- Completion of updates to the existing NPAM Access Database
- Cooperators enter management and vegetation data into the updated NPAM Access Database for the 2011 management year
- Second round of management guidance; management actions for the 2012 management year are recommended to cooperators on August 31, 2011
    - Recommendations are based on the updated decision framework and current state of each management unit (observed via 2011 monitoring)
        - Mixed-Grass
            - Completed two updating cycles and weighted alternative models according to relative credibility
            - Optimal decision policy based on an active adaptive optimization procedure and the updated model weights
        - Tallgrass
            - Optimal decision policy based on a passive optimization procedure and equal model weights
- Hand-Off Meeting, 4th annual cooperator meeting, Jamestown ND (November 2011)
    - Review of the 2011 vegetation and management data, 3-yr plan, accomplishments to date, ancillary studies, components of the updated decision framework, new centralized database, cooperator resources, tallgrass phenology, and implementation phase post hand-off

2012

- Cooperators enrolled 118 management units
    - 82 mixed-grass units, 36 tallgrass units
- Complete development of the centralized InfoPath application of the NPAM database on the web-based Microsoft SharePoint collaboration platform; the centralized database is for use by the cooperators to enter annual management and vegetation data
- Complete development of the localized Access Database for use by the project coordinator to annually process cooperator data
- Second adaptive season
    - Managers select management actions after taking the 2012 recommended management actions into consideration
    - Belt-transect vegetation monitoring occurs during the summer of 2012
- Cooperators enter management and vegetation data into the centralized database for the 2012 management year
- The project coordinator uses the localized database to process the newly entered 2012 data.
- Third round of management guidance; management actions for the 2013 management year are recommended to cooperators on August 31, 2012
    - Recommendations are based on the decision framework and the current state of each management unit (observed via 2012 monitoring)
        - Mixed-Grass
            - Completed a third updating cycle and weighted alternative models according to relative credibility
            - Optimal decision policy based on an active adaptive optimization procedure and updated model weights
        - Tallgrass
            - Completed two updating cycles and weighted alternative models according to relative credibility
            - Optimal decision policy based on a passive optimization procedure and updated model weights

Mixed-Grass and Tallgrass Prairies

Graze

Grazing as a treatment recommendation involves using ungulates to defoliate grasslands. Prescribed grazing describes a certain set of plant-herbivore interactions that will achieve a directional shift of vegetation toward a desired plant community or improvements in a water body (Sedgewick and Knopf 1991). This is different from continuous, season-long grazing, where the objective is more focused on logistics for the cattle (or other ungulate) producer. For the NPAM project, we use 'prescribed grazing' as a treatment that may allow for the increase in native species composition and decrease in invasive species composition.

Smooth brome and Kentucky bluegrass are probably the greatest threats to native prairies. In order to use prescribed grazing to improve or shift the plant community toward a more diverse native community, we need to identify grazing timing and intensity factors that will reduce the vigor of the targeted species while minimizing the impact on desirable species. The key to achieving this is to know how to apply the grazing at the correct stage of development. Plant morphological development of perennial grasses has been divided into four major stages of growth; vegetative, stem elongation, reproductive, and seed ripening (Moore et al. 1991). Several studies have evaluated the effects of defoliation whether by clipping (Mullahey et al. 1991, Reece et al. 1991), grazing (Cullen et al. 1999, Reece et al. 1996), or fire (Engle and Bultsma 1984, Steuter 1987, Wilson and Stubbendieck 1997) on subsequent plant vigor. These authors have identified that plants are most susceptible to injury during the rapid stem elongation phase. Researchers determined that multiple defoliations reduce plant vigor more than a single defoliation (Buwai and Trlica 1977) and stocking rate more than any other factor is the key determinant in whether a plant is defoliated more than once (Hart and Balla 1982, Briske and Stuth 1982, Curll and Wilkins 1982, Pierson and Scarnecchia 1987).

Cattle (and other ungulates) may shift away from the targeted species to non-targeted species, which is a challenge with a prescribed grazing effort where the objective may be to defoliate invasive plants such as smooth brome. In this scenario, once the cattle move from defoliating smooth brome and start to defoliate the cool-season native grasses, they should be removed. In practice utilization levels of 60 to 80% on the smooth brome during this period of time would be desirable, but we may not always be able to target the "optimum" growth stage but come close to it. For example, research conducted in eastern Nebraska with smooth brome, identified that its rapid stem elongation phase occurred in early- to mid-June (Smart et al. 2006). Warm-season grasses like switchgrass and big bluestem started their rapid elongation phase in late-June and early-July, respectively (Mitchell et al. 1998). Therefore the prescribed grazing window may only be a few weeks to maybe two months long. In this scenario, the window is probably the widest. In more northern prairie ecosystems, with less warm-season grasses and more native cool-season grasses this window will be narrower. The difference between smooth brome and natives like western wheatgrass, green needlegrass, prairie junegrass, and needleandthread may not be that great (<2 weeks).

Another consideration is frequency to which this grazing regime takes place. This is not unlike the concept of fire return interval. Studies done by Willson and Stubbendieck (1997) and Steuter (1987) showed that a single burn can be very effective in reducing the biomass of smooth brome or Kentucky bluegrass. However, one to two years post-fire, smooth brome and/or Kentucky bluegrass biomass returned to pre-burned levels (Steuter 1987, Willson and Stubendieck 1997). Annual, or at the very least every other year grazing, may be required to reduce the competition of smooth brome and Kentucky bluegrass.

Burn

The burn treatment requires the use of prescribed fire to defoliate the vegetation on NPAM sites. Fire effects upon native prairie are primarily dependent upon burn interval and timing. The burn interval is determined by eco-region, annual weather factors, grassland condition, and previous management interval. Timing should be based upon species composition and grassland condition.

On degraded grasslands (dominated by smooth brome and Kentucky bluegrass) the initial fire may occur in the spring or fall. The timing of the initial fire is not as important as the amount of consumption. Positive response from native species is dependent upon the removal of litter and duff layer inhibiting seed bed expression. Caution in regard to damaging native species with hot fires may be irrelevant with highly degraded parcels, whereas areas with moderated infestations, there may be concern.

After the initial fire, species composition and fuel load (fuel load is distributed between the duff, litter, and suspended layer) will determine the appropriate fire return interval. If the species composition is dominated by invasive species, fire treatment should be applied as soon as an adequate fuel load to carry a fire is present.

On moderately infested or degraded grasslands in which the plant community responded positively to the initial or subsequent fire (species composition 50% native species), the approach should change from seed bed exposure to increasing the percent compositions of native grass-forb associations, and reduce invasive plant associations. The timing of the next fire(s) should be targeted to positively influence the native species and negatively influence cool-season invasive species. Spring burns conducted at the appropriate growth stage (5-leaf stage) may be effective for reducing smooth brome, which was demonstrated by Willson and Stubbendieck (2000) in the tallgrass prairie. The burn interval will be dependent upon fuel load; a year of rest may be required.

If or when the native plant community becomes re-established (75% native species), the burn interval will be determined by species composition. The re-established prairie would be burned for grassland maintenance (e.g., every 3-4 years). If the percent of invasive species increases, then the interval is shortened and timing is more specific.

Specific to Mixed-Grass Prairie

Burn/Graze Combination

To implement a "Burn/Graze" treatment, both actions must occur within the same management year (i.e. September 1- August 31). Burns can be conducted during the spring or fall, followed by grazing 45-60 growing days post burn. Grazing conducted will be of high intensity for short duration. Stocking rates should be approximately 1 AUM/acre for 30 days. Stocking rate/duration can be adjusted slightly up or down to account for differences in habitat capabilities. The burn -graze ratio should be such that the treatment area is burned a minimum of twice in a ten year period; grazing ratio should be a minimum of twice in a ten year period; and a rest treatment should be incorporated a minimum of once in a ten year period. During years that the treatment area is not burned first, grazing can still be conducted, but should occur early in the growing season, at the same stocking rate and duration as first applied following the burn. To be realistically implemented, treatment combinations may need to be flexible. Flexibility allows for variable effects of treatments on desirable "replacement plants" (e.g., reduce negative effects on certain cool-season native plants because of annual spring grazing) and accounts for unforeseen limitations in applying treatment (e.g., regional burn ban in place during the target window for spring burning) and allows for adjustments required in a region of variable climate, especially deluge and drought. In badly degraded prairies, caution should be taken before applying intensive grazing or conducting a hot fire in prairies where native plants are weakened from long-term rest. Key uncertainties remain that are related to frequency, timing, and intensity of treatments.

Specific to Tallgrass Prairie

Graze within cool-season window

Grazing within the cool-season window as a treatment recommendation involves using ungulates to defoliate grasslands at a certain stage when cool-season invasive species are active and susceptible to damage but warm-season native species are not active and thus not susceptible to damage. Cattle favor smooth brome and the key to injuring this species is multiple rounds of defoliation (several bites on the same plant). The most effective time for injuring smooth brome is when the root system is low in carbohydrate reserves, which occurs twice during the spring growing season. The first period occurs when the tillers are actively growing (i.e., stem elongation and leaf development). The second period occurs when the smooth brome plant is developing floral structures. This second period, however, is not included in the spring cool-season window because warm-season grasses have begun active growth by this time and avoiding damage to the warm-season native species such that they can out-compete smooth brome is the goal. A third period for smooth brome injury occurs during the fall when warm-season native species have gone to seed but smooth brome is in fall re-growth and is building up carbohydrate reserves.

Burn within cool-season window

The burn treatment within cool-season window requires the use of prescribed fire to defoliate the vegetation on NPAM sites at a stage when cool-season invasive species are active and susceptible to damage but warm-season native species are not active and thus not susceptible to damage. The NPAM models for tallgrass prairie have been developed to test Willson and Stubbendieck's (2000) provisional model for using fire to control smooth brome. The premise of their approach is that there is a window of opportunity that will both negatively impact smooth brome and favor native warm-season grasses that compete with smooth brome. We have extended this idea to include both the spring window and the fall window. The best time to injure smooth brome during the spring is when the plant is in the 5-leaf stage. Kentucky bluegrass may be reduced by burning during this same period (i.e., tiller elongation occurring at brome 5-leaf stage), especially during drier than average years. The best time to injure smooth brome and Kentucky bluegrass in the fall is during fall re-green up, when tiller growth of the cool-season invasive grasses has resumed after the summer dormant period and warm-season native species have already gone to seed. Kentucky bluegrass is a poor competitor for moisture compared to most native cool- and warm-season grasses. As such, any burning that reduces soil moisture and snow catch may disfavor Kentucky bluegrass. In some cases removing extensive Kentucky bluegrass litter/thatch/duff is important, particularly on tracts managed previously with long-term rest.

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Native Prairie Adaptive Management Monitoring

SharePoint Database version 6.0 User Guide

July 2012

OVERVIEW

The Native Prairie Adaptive Management Monitoring Database (Database) was developed for the purpose of entering and storing monitoring and treatment data for lands managed under the Native Prairie Adaptive Management Project (NPAM). The NPAM is collaboration between the U.S. Fish and Wildlife Service (FWS) and the U.S. Geological Society (USGS) designed to facilitate management of FWS-owned native prairies in the Prairie Pothole region (spanning FWS Regions 3 & 6). Database version 3.5 was finalized and released to field stations in July, 2010. An updated version of the database, version 5.0, was finalized and released to field stations in July, 2011. A centralized web database was developed in SharePoint 2012 housed on the Department of Interior Connect site in July 2012. This User Guide is updated to reflect database version 6.0.

The NPAM database was a created through the work of many people, including a design team and a programming team.

The following individuals developed the software of the original database, version 3.5, in Microsoft Access:

Kevin McAbee – FWS Region 6 – Utah Ecological Services Field Office
Todd Sutherland – FWS Region 3 – Biological Monitoring and Database Team

Sarah Jacobi of Chicago Botanical Garden updated and modified version 3.5 of the database to create the 5.0 version and again modified the Access database 6.5 to import the data from the SharePoint application. The Access database 6.5 will now be used by the NPAM coordinator to generate the recommended management actions each year.

Vicky Hunt with the Chicago Botanical Garden created the first version of the centralized NPAM web database 6.0 which allows cooperators to enter all monitoring and management action data in SharePoint 2010.

Members of the NPAM Science Team, and other individuals, provided design criteria and tested the database for functionality before final release to all field stations. These individuals include:

Kim Bousquet – FWS Region 3 – Big Stone National Wildlife Refuge
Cami Dixon – FWS Region 6 – Division of Biological Resources
Pauline Drobney – FWS Region 3 – Neal Smith National Wildlife Refuge
Justin Dupey – FWS Region 6 – Huron Wetland Management District
Vanessa Fields – FWS Region 6 – Benton Lake National Wildlife Refuge
Todd Grant – FWS Region 6 – J. Clark Salyer National Wildlife Refuge
Sara Vacek – FWS Region 3 – Morris Wetland Management District
Jennifer Zorn – FWS Region 6 – Division of Biological Resources
Jill Gannon – USGS – Northern Prairie Wildlife Research Center
Clint Moore – USGS – Patuxent Wildlife Research Center
Terry Shaffer – USGS – Northern Prairie Wildlife Research Center
Volunteer Cooperators:
Kristine Askerooth –Tewaukon NWR and Brent Jamison – Huron WMD

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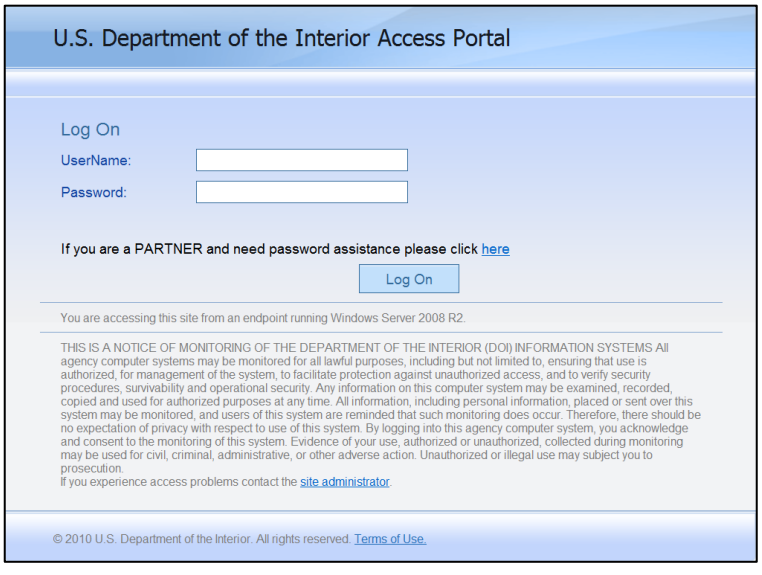
OVERVIEW

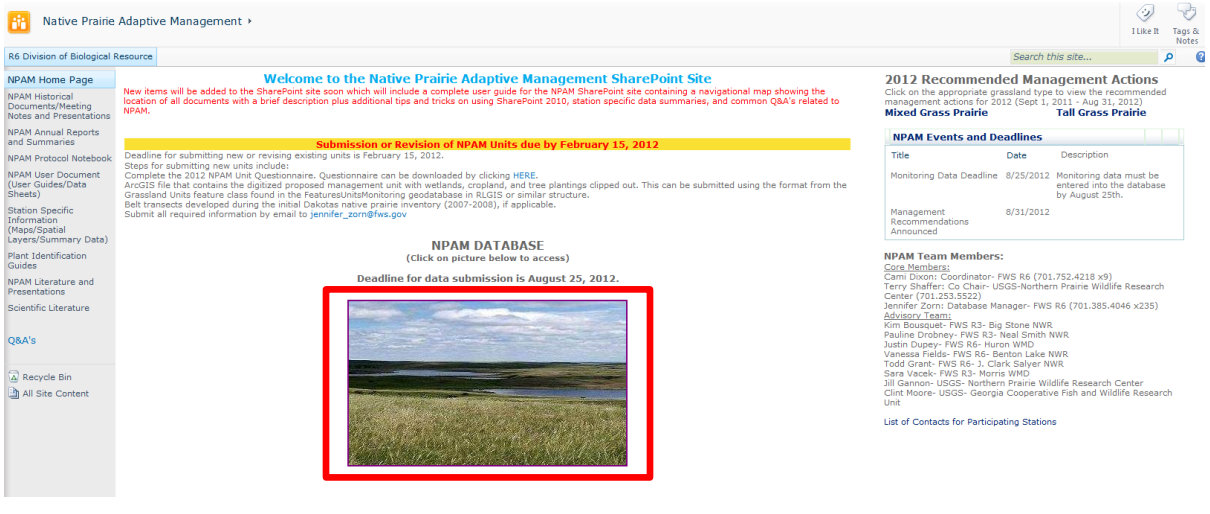
Access to the centralized NPAM SharePoint Database will be provided to the primary and secondary contact for each participating station. Permissions will be restricted to ensure data quality. Participating stations can access the database by navigating to the NPAM home page located at https://connect.doi.gov/fws/Portal/R6DBR/NPAM/default.aspx and clicking on the NPAM database icon.

NPAM SharePoint Site

NPAM Database is hosted on the DOI Connect SharePoint Site. The username and password is your FWS email and active directory password. (https://connect.doi.gov/fws/Portal/R6DBR/NPAM/default.aspx)



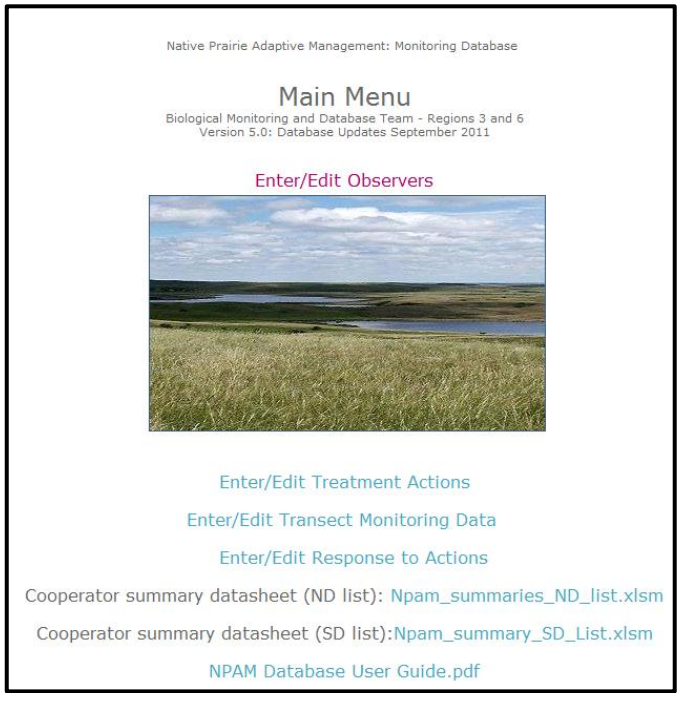
To access the database main menu click on the NPAM database picture located on the home page



NPAM MAIN MENU

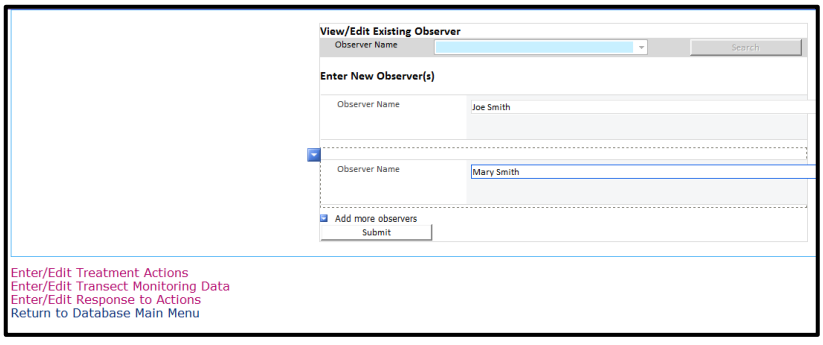
The main menu contains the links to four steps that need to be completed on a yearly basis.

1. Enter/Edit Observers
2. Enter/Edit Treatment Actions
3. Enter/Edit Monitoring Data
4. Enter/Edit Response to Actions



Enter/Edit Observers

1. Enter observer names for people that collected monitoring data or applied treatment actions. Click in the empty box right of 'Observer Name'; enter the first and last name of the observer.
2. To enter more than one name click on 'Add more observers' and continue to add names. Once you have all the names entered hit 'Submit' to save. You have the option to navigate back to the Main Menu or select Treatment Actions, Monitoring Data, or Response to Actions forms.



3. To query existing date click on the arrow next to 'edit user name' to see the list of observer names that already exist in the database. You will not be able to submit a name that already exists in the database but you can edit an existing name. A red dashed box will appear around the name if there is a duplicate name.

Enter/Edit Treatment Data

1. To enter new data complete the orange boxes to set the default fields. Select the complex and enter the correct password for that complex. * All data in the Management Actions is locked with a password for each complex. The password was sent to the primary and secondary contact for each station.
2. Select Management Unit
3. Select Management Unit Contact. If the person responsible for the treatment action is not listed scroll to the bottom of the page and click on the 'Enter/Edit Observers' and follow the steps listed under that section. Note, if you navigate to the 'Add/Edit Observer' you will lose any existing data for the treatment actions.
4. Select the '**Management Year**', which is the year, as defined by NPAM, in which the treatment took place. A description of the management year is found to the right of the year. For example, any treatment that took place from September 1, 2008 to August 31, 2009 is considered to take place in management year 2009.
5. Select the '**Management Type**'**,** which is limited to the three or four NPAM choices based on the Grassland Type (Mixed or Tall Grass Prairie) for the management unit.
6. Enter the '**Start Date**' and '**End Date**' for the treatment. You can enter the dates using the calendar or manually (format mm/dd/yyyy).
    - For **Rest** treatments, the start and end dates will be automatically set to the beginning and ending dates of the chosen management year. These dates cannot be edited.
7. After the Unit is selected, the '**Native Sod Uplands**' field will be auto-populated with the native sod portion of the unit, in acres, retrieved from GIS. This field is grayed-out and is not editable; it is primarily there as a reference for the user.

8. Enter the '**Native Sod Uplands Treated**'. If the entire native sod portion of the unit was treated, enter the number as seen in the '**Native Sod Uplands**' field just above. If for some reason only a portion of the native sod on the unit was treated, for example, a partial prescribed burn, enter the number of acres that was treated. The number entered must be greater than zero but less than or equal to the value in the '**Native Sod Uplands**' field above.
9. After the management type is selected, if other than '**Rest**', a secondary form will appear to the right allowing the user to enter required treatment specific data. The tab will default to the specific management type that was selected. For example, if '**Graze**' is selected, the user will only be able to enter data in the fields of the '**Grazing Data**' tab; all other tabs will be grayed-out and will not be editable. See the section on 'Treatment Specific Data' below for more details on these fields.

Warning: When the management type is changed, the previous treatment specific data entered in the secondary form will be lost. For example, if a user selected '**Graze**' as the management type and entered grazing specific data in the fields of the '**Grazing Data**' tab (i.e., Number of animals, Grazing Animal Type, Stocking Rate, and Grass Utilization) and then changes the management type to '**Burn**', the grazing specific information that was entered will be lost and the user will need to enter data in the fields found in the '**Burning Data**' tab that are relevant to the '**Burn**' treatment selected. There is no 'undo' function. The **Start Date**, **End Date**, and **Native Sod Uplands Treated** fields will remain as initially entered; however, you will be prompted to verify that these fields are still accurate for the newly selected treatment and to change them accordingly if they are not accurate.

10. For Tall Grass Prairie units, additional **'Phenological Stage'** field(s) within the '**Grazing Data**' and '**Burning Data**' tabs will appear. The drop down list for each phenological stage is determined by the **Start Date**. **For this reason, the user must fill the dates in first before entering the phenological data.** See the section on 'Treatment Specific Data' below for more details on these fields.

Special Note about Combination Treatments:
For a Burn/Graze combo, a user must enter each treatment individually in two separate records: one for the **Burn** treatment and one for the **Graze** treatment. For example, a prescribed burn in March followed by a graze in August must be entered as two separate treatments, in two separate records, that occur during different dates.

Similarly, for rotational grazing, each instance of grazing must be entered separately. That is, if the unit is grazed for a week in June, the cattle are removed, and then the unit is grazed for another week in July, these two grazing events must be entered as two separate records.

11. If any "special treatments" (i.e., treatments other than the recognized NPAM treatments in the **Management Type** drop down list) were applied to the management unit during the management year, the user must select the check box next to 'Special treatment?' After submitting the data you must click on 'Enter Special Treatment' link at the bottom of the form to enter the information. Note: The special treatment window doesn't automatically open after checking the box.

12. To enter addition treatment actions using the same default values (Orange colored boxes) click on 'Open additional forms' and then on 'Copy' to auto fill the orange boxes. Note: The data is not saved until you click 'Submit'

*Remember to check if there are any red boxes showing around any of the attributes that need to be populated. If a red box exists you can't submit the data until those are fixed. If you fixed all the red error boxes and the Submit button is still grayed out, check to see if the password was typed correctly for the complex selected.

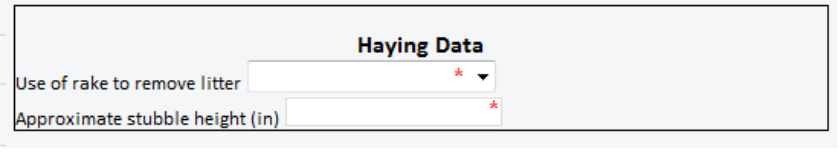
****

TREATMENT SPECIFIC DATA

After the '**Management Type**' is selected, if other than **Rest**, a secondary form will appear to the right. This secondary form contains other attributes for '**Haying Data**', '**Grazing Data**', and '**Burning Data**'. This form contains required fields for the treatment specific data. The secondary form will default to the specific management type that was selected. For example, if **Graze** is the selected management type, the user will only be able to enter data for the fields within the '**Grazing Data**' form; all other management type forms will not be available unless you change the 'Management Type'.

Haying Data (Tall Grass Prairie Units Only)

- The **Use of Rake to Remove litter** is a yes/no question indicating whether or not litter was removed after the haying treatment.
- The **Approximate Stubble Height** is recorded in inches. Enter this value manually.

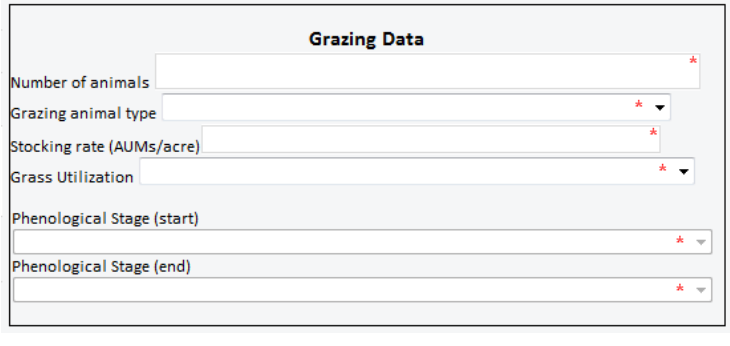


b. **Grazing Data**

- Record the **Number of Animals** and **Grazing Animal Type** used.
- The **Stocking Rate** is calculated by the manager and recorded in AUMs per acre.
- The **Grazing Utilization** is a qualitative pull down describing the approximate intensity of the graze. This is a visual assessment for which the user has separate guidelines on how to make.

Use Rating Class	Use of Current Year's Growth[1]	Whole-Pasture Use Description
UNUSED	0%	No livestock use
SLIGHT	1 to 20%	Appears practically undisturbed when viewed obliquely. Only choice plants and favored areas near water, trails, or shade are grazed.
MODERATE	21 to 40%	Most all of accessible pasture shows grazing. Little or no use of poor forage. Little evidence of trailing to grazing.
FULL	41 to 60%	All fully accessible areas are grazed. The major sites have key forage species properly utilized (about 1/2 taken and 1/2 left).[2] Points of concentration with overuse limited to between 5% and 10% of accessible area.
CLOSE	61 to 80%	All accessible pasture plainly shows use and major sections are closely cropped. Livestock forced to use much poor, dry, and stemmy forage considering seasonal preference.
SEVERE	81 to 100%	Key forage species almost completely used. Low-value forage carrying grazing load. Trampling damage widespread in accessible areas.

- **For tallgrass units only**. The user must enter the **Phenological Stage** of the unit on the Start Date that the grazing treatment began and on the End Date that the grazing treatment ended. The user selects the stage from a drop-down menu. The choices in the drop-down menu depend on the Start Date of the grazing treatment. If the Start Date is before January 1 of the management year, the phenological descriptions are relative to the fall season. If the Start Date is January 1 or later of the management year, the phenological descriptions are relative to the spring season. Because it may be difficult for managers to be present on the site when the grazing animals are put on or taken off the unit, there is an option to select "Not able to visit site to assess at time of event".



c. **Burning Data**

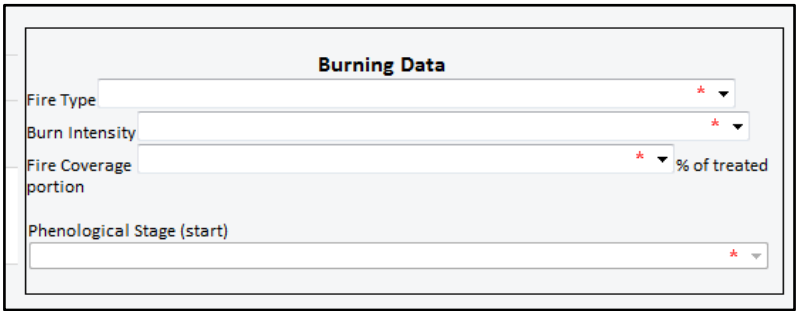
- The **Fire Type** is either a prescribed or wildland (natural) fire.

- The **Burn Intensity** provides a list of qualitative descriptions of the fire. The burn intensity is affected by the firing techniques (e.g., backing fire, head fire), firing pattern, vegetation dryness or green-up,

and weather conditions during the burn. A complete description is found in the table below:

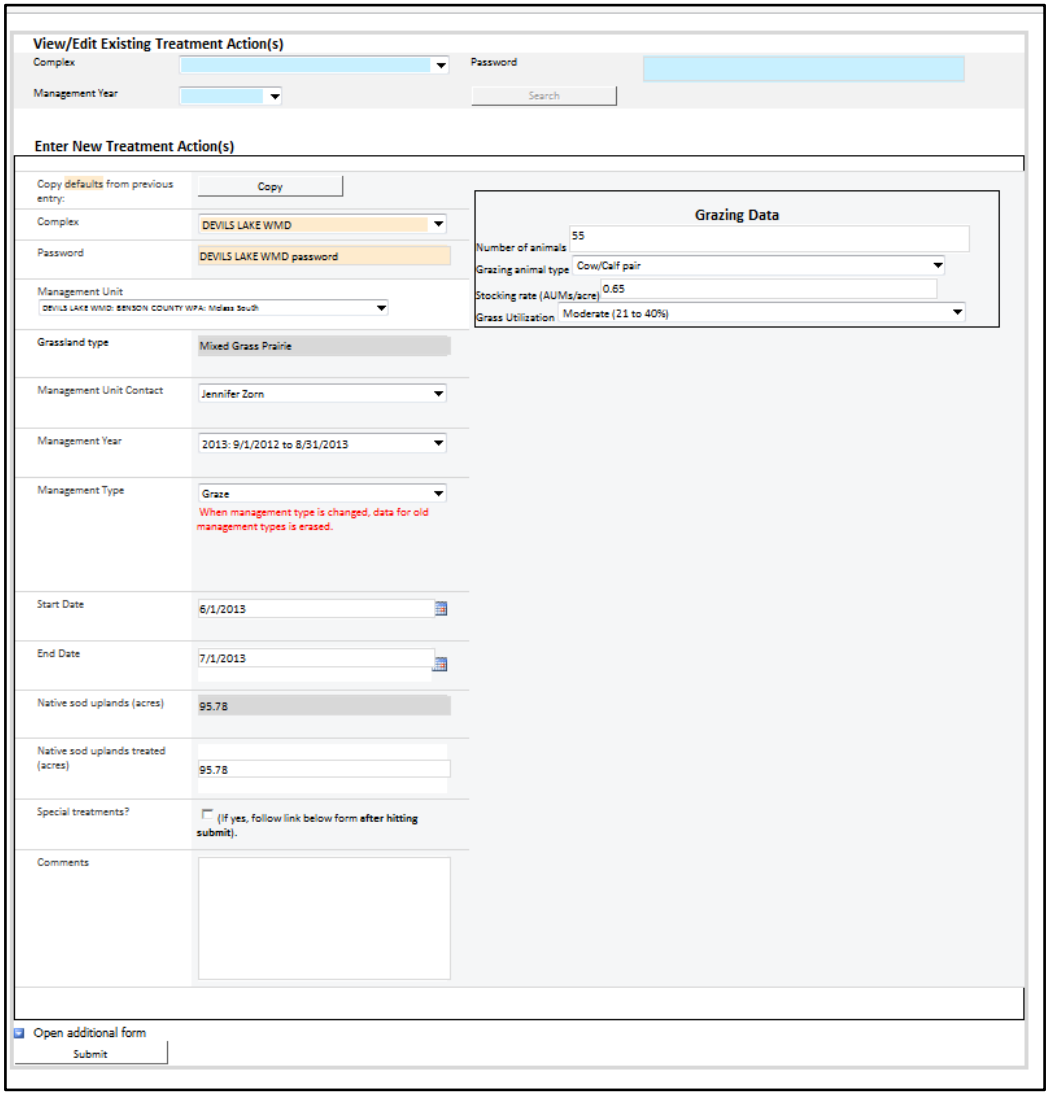
- The **Fire Coverage** is the portion of the total native sod uplands on the management unit that was actually burned.

- **For tallgrass units only**. The user must enter the **Phenological Stage** of the unit on the Start Date of the Burn. The user selects the stage from a drop-down menu. The choices in the drop-down menu depend on the Start Date of the burning treatment. If the Start Date is before January 1 of the management year, the phenological descriptions are relative to the fall season. If the Start Date is January 1 or later of the management year, the phenological descriptions are relative to the spring season.



	Substrate	Vegetation
Unburned	Not burned	Not burned
Scorched	Litter partially blackened; duff nearly unchanged; leaf structure unchanged	Foliage scorched
Lightly burned	Litter charred to partially consumed, but some plant parts are still discernible; charring may extend slightly into soil surface, but soil is not visibly altered; surface appears black(this soon becomes inconspicuous); burns may be spotty to uniform depending on the grass continuity	Grasses with about two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable
Moderately burned	Leaf litter consumed, leaving coarse, light gray or white colored ash immediately after the burn; ash soon disappears leaving bare mineral soil; charring may extend slightly into soil surface	Unburned grass stubble usually less than two inches tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning; burns tend to be uniform
Heavily burned	Leaf litter completely consumed, leaving a fluffy fine white ash, this soon disappears leaving bare mineral soil; charring extends to a depth of 1 cm(0.5 in) into the soil; this severity class is usually limited to situations where heavy fuel load on mesic sites has burned under dry conditions and low wind	No unburned grasses above the root crown; for other species, all plant parts consumed leaving some or no major stems or trunks, any left are deeply charred; this severity class is uncommon due to the short burnout time of grasses
Not applicable	Inorganic preborn;	None present preborn;

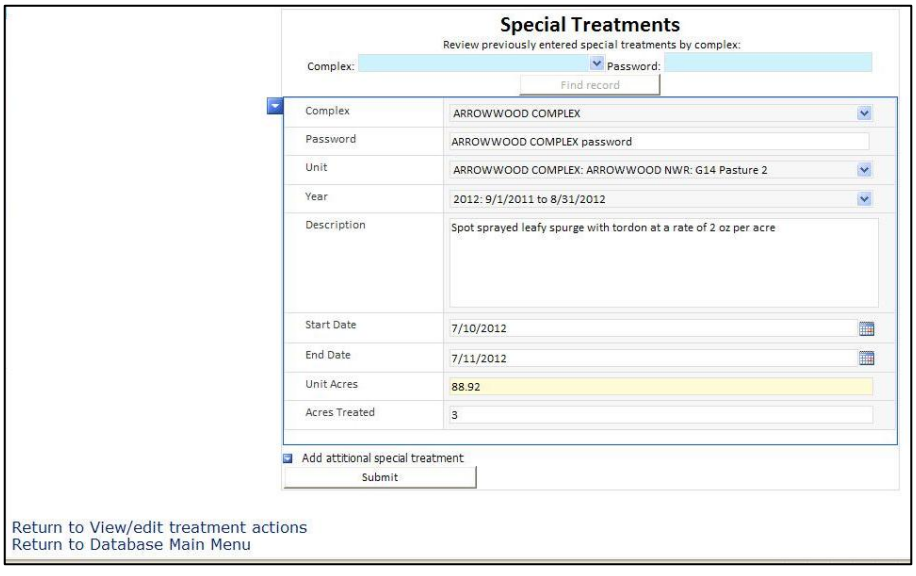
13. To query existing date fill in the field in blue (Complex, password, and mgmt. year) and click search. Once the search is complete a list of all records that match the query fields will display below. If you need to edit existing data, make changes where appropriate and click 'Submit' at the bottom of the page. If you would like to add new records after you compeleted a query click on 'Open additional forms' at the bottom and either enter all new information or click on 'Copy' button to copy the last submitted records default fields (orange boxes).



Enter Special Treatment

1. Enter Special Treatment Information
   - The user enters a description of the special treatment in the **Description** field. The **Start** and **End** dates are entered the same way as they are on the main Management Form (i.e., using

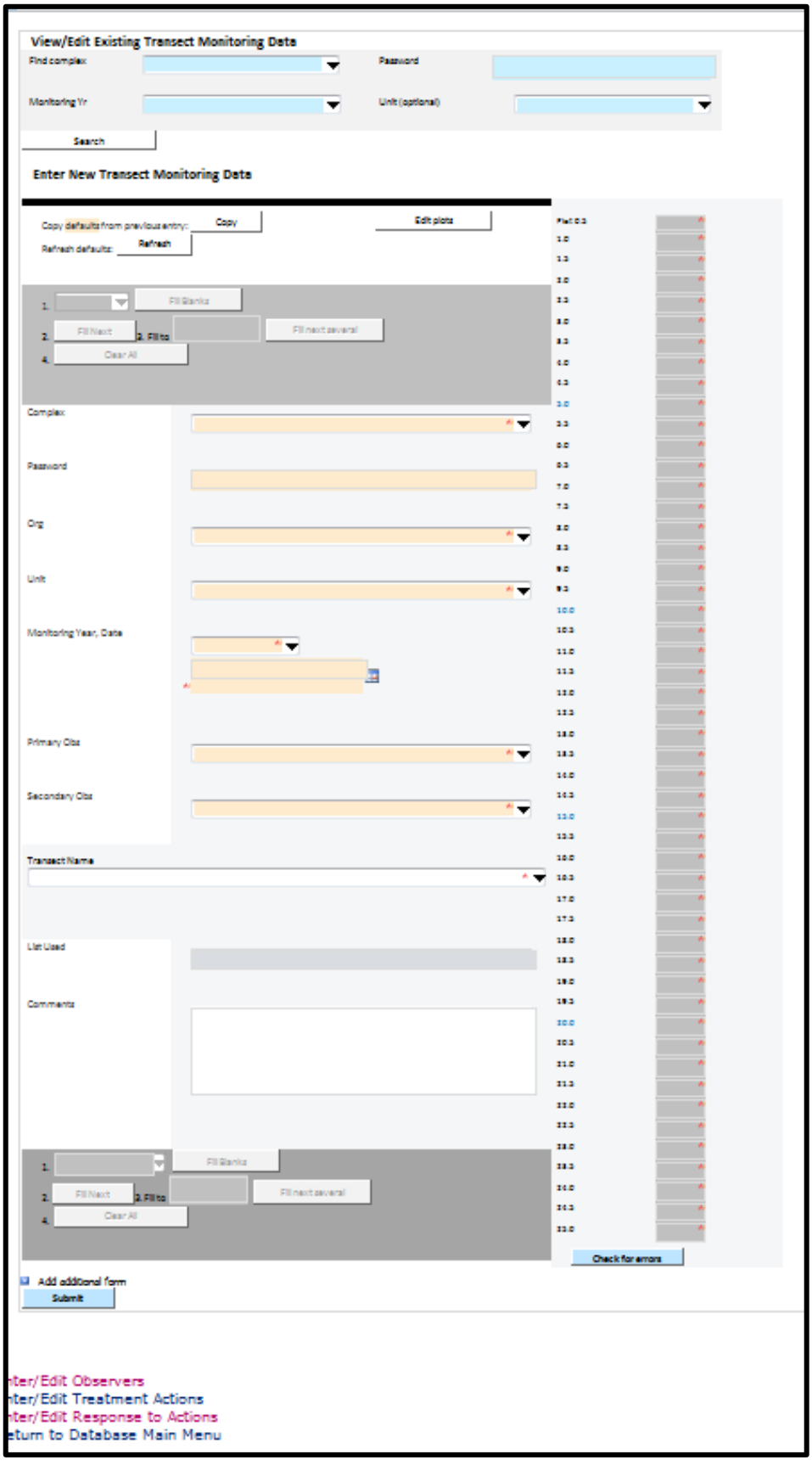
the calendar or manually in the format mm/dd/yyyy). The **Acres Treated** must be a value greater than zero and less than or equal to the full size of the **Native Sod Uplands** on the unit. You may enter multiple special treatments for the same NPAM unit. Once you're done filling in the information, hit the submit button and return to either the main menu or treatment actions form.



Examples of Special treatments include spot spaying chemical for invasive or noxious weeds, spot mowing invasive or noxious weeds, or hand-pulling invasive or noxious weeds.

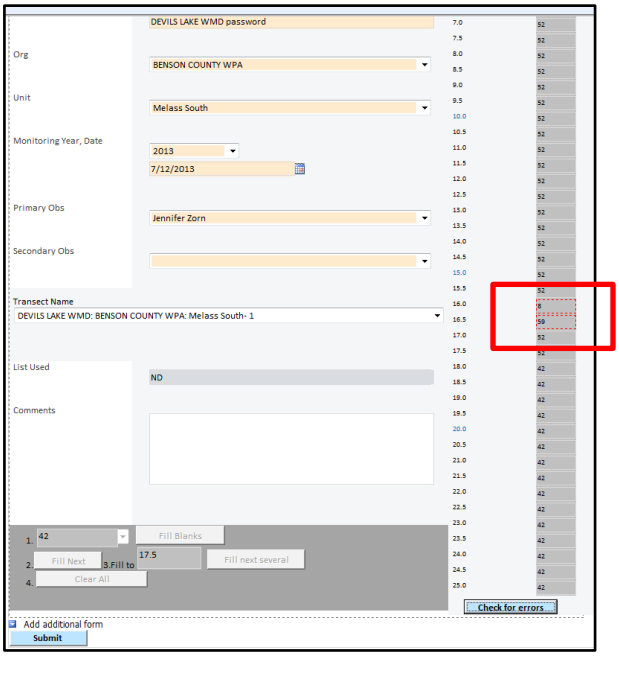
Enter/Edit Transect Monitoring Data

1. To enter new data complete the orange boxes to set the default fields. Select the complex and enter the correct password for that complex. Enter the Org, Unit, Monitoring Yr., Date, Primary obs, Secondary obs, and select the confirm unit. * All data in the Transect Monitoring Section is locked with a password for each complex. The password was sent to the primary contact for each station.


View/Edit Existing Transect Monitoring Data
Find complex
Password
Monitoring Yr
Unit (optional)
Search
Enter New Transect Monitoring Data
Copy defaults from previous entry:
Copy
Edit plots
Refresh defaults:
Refresh
Fill Blanks
Fill Next
2. Fill to
Fill next several
Clear All
Complex
Password
Org
Unit
Monitoring Year, Date
Primary Obs
Secondary Obs
Transect Name
List Used
Comments
Check for errors
Add additional form
Submit
ter/Edit Observers
ter/Edit Treatment Actions
ter/Edit Response to Actions
eturn to Database Main Menu

2. Scroll up and hit 'Edit plot' to populate Plot 0.5-25. The plot data is greyed out until you click 'Edit Plot', once it is in edit mode the plot boxes will turn green. Options for filling in the plot data include manually entering the plant code and 'Tab' button on your keyboard to advance to the next plot number and/or use the fill buttons located in the green section (two locations).
    - 1. Fill Blanks – use the drop down list to select the plant code you would like to fill in for all blank plots.
    - 2. Fill Next – fill the next plot with the same plant code above.
    - 3. Fill next several – Enter the plot number you wish to fill the previous entered plant code to.
    - 4. Clear All – Will clear the entire plot data. *The fill buttons only work for plots that do not have existing data.

3. Once you entered plot data for a transect, you must click on the 'Check for errors' located at the bottom of the plots data before the data can be submitted. This checks all 50 plots to make sure that a valid plant code was entered. If there are any red boxes round a plant code, that code was invalid. You must go up and click on 'Edit plots' button again and fix the errors before you can submit the data.

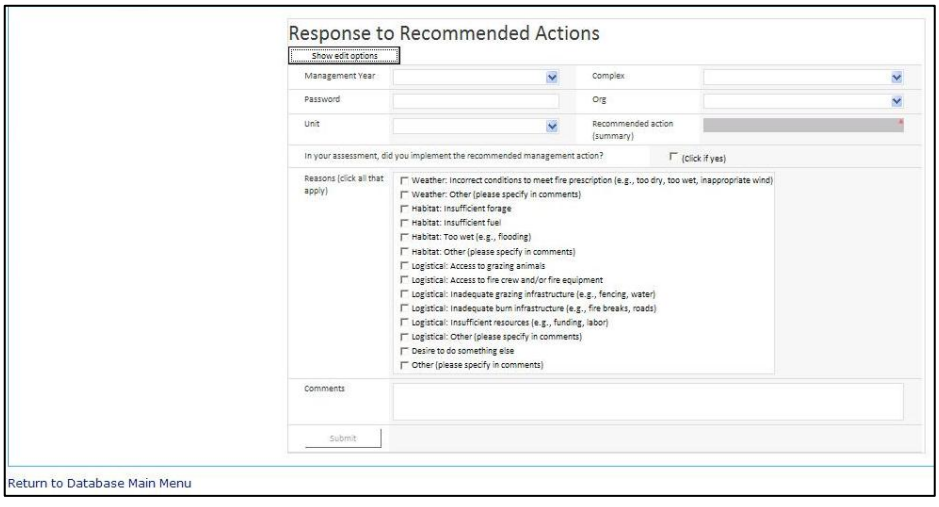


4. After you 'Check for errors' you can submit you monitoring data. To save all the transect data you must hit the 'Submit' button. After you hit the 'Submit' button you will get a message box saying the data was submitted successfully and return you to a fresh Monitoring Data Form or you will receive an error message. All errors will have a red dashed box around the attributes that need attention. * By clicking the 'Submit' button you set the default values for the next transect.
5. To enter data for a new transect click on 'Copy' button to fill in the orange default boxes, scroll down and select a new transect and repeat step 2-3.
6. To continue entering data for other transect with the same default values click on 'Add additional form' and repeat steps 2-3. *Caution, if you enter too many transects at one time you may get an error stating you exceeded the limit. Do not enter data for more than 8 transects at one time without hitting the 'Submit' button.
7. To save all the transect data you must hit the 'Submit' button. After you hit the 'Submit' button you will get a message box saying the data was submitted successfully and return you to a fresh Monitoring Data Form or you will receive an error message. All errors will have a red dashed box around the attributes that need attention.

   * By hitting the 'Submit' button, the last entry will set the default values.

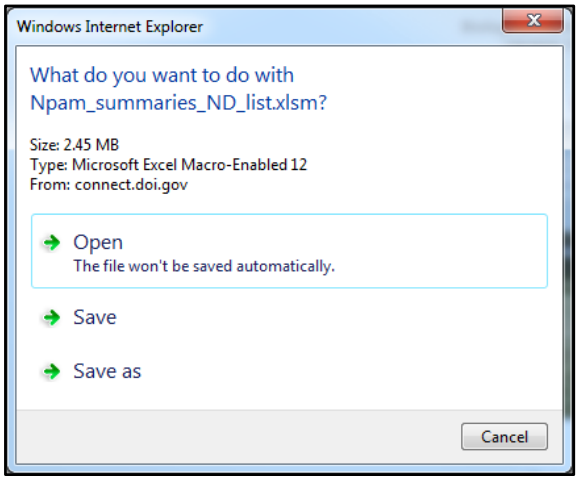
Enter/Edit Response to Actions

1. From the main menu click on 'Enter/Edit Response to Actions'
2. Select Management Year, Complex, Password, Org, and Unit. After you select the Unit the recommended action for the Management Year will automatically populate in the grey box.
3. Check the box if you implemented the recommended management action. If you did not implement the recommended action then check all the reasons that apply in the box below. Please add any comments as to why the recommend treatment action was not completed.
4. Repeat steps 2 and 3 for all units in your complex.

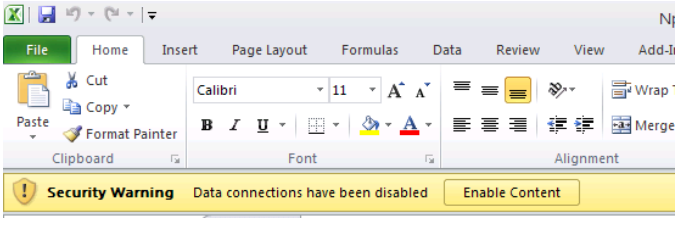


Cooperator Summary Datasheets

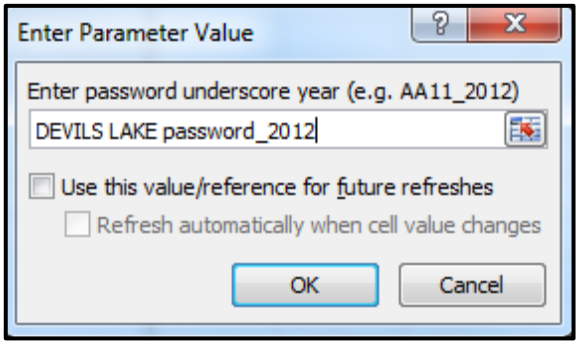
1. From the main menu click on the appropriate link to either the ND plant code list or SD plant code list. (Units in MT, ND, MN use ND plant list, units in SD use SD plant list).
2. Click 'Open' from the Windows Internet Explorer box.



3. If a yellow Security Warning shows on the top of the excel sheet, click on "Enable Content'



4. Enter the password for the complex you wish to retrieve data. (Same password used to enter data) followed by and "_" and year. Click OK.



5. The excel sheet will open up with all the data for the complex. There are several tabs on the sheet. The following pages describe the summaries that were created for each transect/unit. To save the excel file, go up to file, save as and navigate to a location on your computer or sever where you would like to store the summary datasheet.

BASIC DATA QUERIES USING NORTH DAKOTA AND SOUTH DAKOTA PLANT LISTS

Basic frequency calculation and potential storage and/or exportation of transect data

Each 25-m transect is composed of 50 0.5-m segments. Frequency for each plant group is derived by summing the number of belt segments classified for each group (e.g., 41 native cool-season prairie [ND list]) and dividing by 50, the total number of segments. Convert proportional frequencies to percentage by multiplying by 100.

Below is a description of 6 basic summaries we have found useful. Queries are first derived for EACH TRANSECT. To fill the "query categories", frequency data for relevant plant groups are simply added together according to the query (e.g., using the SD list, we derive the percentage of low-shrub (Life Form Query) by adding plant groups 11-14. Data are usually summarized for each management unit or alternatively for each complex (i.e., data are averaged across all transects that comprise the management unit – measures of variation [i.e., summary statistics should be provided based on the number of transects summarized]). Pages that follow show ND and SD plant lists, plus basic queries associated with each list. Again, for each query, plant groups are added together to get values for query categories.

Query 1) Life Form

What proportion each management unit is composed of 4 major life form categories: 1) grass-forb, 2) low shrub, 3) tall shrub, and 4) tree? This query primarily addresses the degree to which units are invaded by woody vegetation. A unique forb component also can be derived by subtracting transects = "49" from the grass-forb component 1 above for the ND list and "25" for the SD list.

Query 2) Degree of Invasion (grass-forb categories only)

What proportion of each management unit is 1) mostly invaded by introduced plants, 2) somewhat invaded by introduced plants, or 3) in near pristine condition? This query can only be used for the ND list. It describes current state and restoration potential of management units. Units with a high proportion of "mostly invaded" are less likely to be restored or more costly to restore. Units in pristine condition can be considered in a maintenance phase. "Somewhat invaded" units offer restoration opportunities above those that are "mostly invaded".

Query 3) Grass-forb Composition

What proportion of each management unit is dominated by 1) native grass-forb, 2) Kentucky bluegrass, 3) smooth brome, 4) quackgrass, 5) crested wheatgrass, and 6) weedy forb categories? Woody vegetation categories are excluded. This is the query most useful for the NPAM project. Also, this is the principal query used to identify restoration issues (e.g., KY bluegrass vs. smooth brome vs. weedy forbs) for a unit. Depending on type and degree of invasion, specific (short- and long-term) management prescriptions are formulated. For those using the SD plant list, this query is an analogous (but less informative) substitute for the query #2 above: "degree of invasion (grass-forb only)".

Query 4) Low shrub Composition

What proportion of each management unit is composed of different low-shrub types, including 1) snowberry, 2) silverberry, 3) meadowsweet, and 4) other types? This query can only be used for the ND list and is most relevant for units with known invasions by woody vegetation that differ substantially from the presettlement period (see life form query). Depending on type and degree of invasion (e.g., silverberry vs. snowberry), specific management prescriptions may be formulated.

Query 5) Understory Composition of Low Shrub Community

Given the low shrub component, what is the predominant understory vegetation type, including 1) native grass-forb, 2) Kentucky bluegrass, and 3) smooth brome? This query can only be used for the ND list and is most relevant for tracts with known woody vegetation invasions (see life form query). Low shrubs, especially western snowberry are often transitional sites. Historically these sites were often dominated by mesic warm-season native vegetation; smooth brome or Kentucky bluegrass are predicted to replace many low-shrubs, especially under rest-dominated management. As such, degraded low shrub communities may be considered invasion sites for bluegrass or brome.

Query 6) Weedy Forb Composition

What proportion of each management unit is dominated by 1) leafy spurge, 2) Canada thistle, 3) wormwood, 4) sweet clover, or other 5) introduced weeds? The total frequency of all weedy forb groups is derived from the query of "Grass-forb Composition". This query provides information on the relative importance of different weedy forbs in compromising the integrity of management units. Depending on

type and degree of invasion, unique, specific short- and long-term management prescriptions are formulated.

North Dakota Plant List	
Description of class	*Code*
snowberry dense; other plants few or none	11
snowberry; remainder mostly NATIVE grass-forb types	12
snowberry; remainder mostly Kentucky bluegrass	13
snowberry; remainder mostly smooth brome (or quackgrass)	14
silverberry; add modifier 15[2] = NATIVE grass-forb, 15[3] = KY bluegrass, 15[4] = brome (or quack), 15[5] = cre	15
silverberry/natives	152
silverberry/ky blue	153
siverberry/brome	154
snowberry; remainder mostly crested wheatgrass	16
meadowsweet; add modifier as above 18[2], 18[3], or 18[4], 18[5] = crested	18
meadowsweet/natives	182
meadowsweet/ky blue	183
meadowsweet/brome	184
other low shrub (user defined – add modifier)	19
native shrub (chokecherry, buffaloberry, hawthorn, willow)	21
shrub-stage aspen	22
introduced shrub (caraganna, Russian olive)	23
aspen	31
shade-tolerant woodland tree (green ash, box elder, American elm)	33
oak	34
introduced tree (Siberian elm, Juniper, spruce)	35
dry cool season (sedges, green needlegrass, needle-and-thread, wheatgrass spp., prairie junegrass, forbs)	41
dry warm season (little bluestem, prairie sandreed, blue gramma, frobs)	42
mesic cool-warm mix (big bluestem, switchgrass, porcupine grass, prairie dropseed, forbs)	43
meadow (fowl bluegrass, foxtail barley, northern reedgrass, fine-stem sedge spp., baltic rush, cordgrass).	46
wetland; robust emergent vegetation or open water (cattail, river bulrush, bur-reed, phragmites, manna grass)	47
clubmoss/lichen	48
native forb	49
Kentucky bluegrass >95% (or >50% if mixed with other non-natives)	51
Kentucky bluegrass and NATIVE grass-forbs, KY bluegrass 50-95%	52
NATIVE grass-forbs and Kentucky bluegrass, KY bluegrass 5-50%	53
smooth brome >95% (or >50% if mixed with other non-natives)	61
smooth brome and NATIVE grass-forbs, brome 50-95%	62
NATIVE grass-forbs and smooth brome, brome 5-50%	63
crested wheatgrass >95% (or >50% if mixed with other non-natives)	71
crested wheatgrass and NATIVE grass-forbs, crested wheatgrass 50-95%	72
NATIVE grass-forbs and crested wheatgrass, crested wheatgrass 5-50%	73
quackgrass >95% (or >50% if mixed with other non-natives)	74
quackgrass and NATIVE grass-forbs, quackgrass 50-95%	75
NATIVE grass-forbs and quackgrass, quackgrass 5-50%	76
reed-canary grass	77
tall, interm, or pub wheatgrass	78
other introduced grass (user defined)	79
leafy spurge	81
Canada thistle	85
wormwood	87
other introduced weeds (user-defined)	88
barren/unvegetated (e.g., rock, anthill, bare soil); dead vegetation	91
tall introduced legume: sweet clover of alfalfa	98
other – user defined	99

Summation of categories for several basic data queries ND List

Life Form	
Grass-forb	40s, (Exclude 47), 50s, 60s, 70s, 80s, 98
Low shrub	11-19
Tall shrub	20s
Tree	30s
Forb only	49

Degree of Invasion (grass-forb only)	
Mostly invaded	51, 52, 61, 62, 71, 72, 74, 75, 77, 78, 81, 85, 87, 88, 98
Somewhat invaded	53, 63, 73, 76
Devoid of invasives “pristine”	41, 42, 43, 46, 48, 49 (Exclude 47)

Grass-forb Composition	
Native-dominated	41, 42, 43, 46, 48, 49, (Exclude 47), 53, 63, 73, 76
Kentucky bluegrass-dominated	51, 52
Smooth brome-dominated	61, 62
Quack grass-dominated	74, 75
Crested wheat grass-dominated	71, 72
Reed-canary grass-dominated	77
Weedy forb-dominated	80s, 98

Composition of Low Shrub Types	
Snowberry	11-14, 16
Silverberry	15s
Meadowsweat	18s
Other low shrub	19

Understory of Low Shrub Types	
Native low shrub/native	11, 12, 15, 15.2, 18, 18.2
Native low shrub/kentucky bluegrass	13, 15.3, 18.3
Native low shrub/brome	14, 15.4, 18.4
Native low shrub/crested wheat grass	15.5, 16, 18.5

Weedy Forb Composition	
Leafy spurge	81
Canada thistle	85
Wormwood	87
Sweet clover, alfalfa	98
Other noxious weed	88

South Dakota Plant List	
Description of class	*Code*
dense low shrub, other plants few or none	11
low shrub, remainder native grass and forb	12
low shrub, remainder KY bluegrass	13
low shrub, remainder brome or quackgrass	14
low shrub, remainder crested	19
tall shrub, native	15
tall shrub, exotic	16
native trees (e.g. cottonwood, green ash, bur oak)	17
non-native trees (e.g. Japanese elm, Russian olive)	18
cool season grasses & forbs A) green needle, B) western wheatgrass, C) porcupine grass	21
warm season grasses & forbs A) big bluestem, B) switch, C) Indian, D) little bluestem	22
meadow (sedges, baltic rush, dock, smartweed, cordgrass, reedgrass, horsetail, foxtail barley, etc.)	23
wetland; robust emergent vegetation or open water (cattail, river bulrush, bur-reed, Phragmites, manna grass)	24
forb	25
Kentucky bluegrass dominant	31
smooth brome dominant	41
crested wheatgrass dominant	51
quackgrass	52
reed-canary grass	53
tall, intermediate, or pubescent wheatgrass	61
other non-native grass – user defined (downy/Japanese brome, etc.)	62
leafy spurge	71
canada thistle	72
sow thistle	73
wormwood	74
other weeds (kochia, ragweed, cocklebur, etc.)	75
other noxious weed (user-defined)	76
tall introduced legume (sweet clover or alfalfa)	81
cactus	83
clubmoss/Lichen	84
barren, unvegetated (bare soil, gopher mound)	91
other (rock, manure, hole, ant hill)	92

Summation of categories for several basic data queries SD List

Life Form	
Grass-forb	20s, (Exclude 24), 30s, 40s, 50s, 60s, 70s, 80s
Low shrub	11-14, 19
Tall shrub	15, 16
Tree	17, 18
Forb only	25

Grass-forb Composition	
Native-dominated	21, 22, 23, (Exclude 24), 25, 83, 84
Kentucky bluegrass-dominated	31
Smooth brome-dominated	41
Quack grass-dominated	52
Crested wheat grass-dominated	51
Reed-canary grass-dominated	53
Weedy forb-dominated	70s, 81

Understory of Low Shrub Types	
Native low shrub/native	11, 12
Native low shrub/kentucky bluegrass	13
Native low shrub/brome	14
Native low shrub/crested wheat grass	19

Weedy Forb Composition	
Leafy spurge	71
Canada thistle	72
Sweet clover, alfalfa	81
Other noxious weed	73, 74, 75, 76

Native Prairie Adaptive Management (NPAM) Project
2013 Management Year

Service-owned Management Unit Background Information

Please fill out the following questionnaire *electronically* for each management unit you would like to add to the NPAM project in 2013. Submit via e-mail to Jennifer Zorn (jennifer_zorn@fws.gov) *by Friday, February 15, 2013*. For purposes of this questionnaire, a "unit" is the smallest parcel of land that receives only a single management treatment at any time over its entire extent. For example, a management unit might be an entire 80-acre WPA or it might be a 120-acre fenced parcel within a larger tract (refuge or WPA). The focus is *native sod* (i.e. unbroken ground), but the entire unit need not be native sod.

1. Name of Station: _____ Contact Person: _____
2. Name of Unit: _____
3. Location: Provide one shapefile that includes all new management units. Even if the overall unit is larger, limit the shapefile to the native sod with wetlands and old cropland clipped out. Use the Grassland Units feature class from the Features, Units, and Management (FUM) Geodatabase in RLGIS and label these fields: Organization Code, Complex or WMD Name, Organization Name, Unit Name, Subunit Name, RSL Type, State, FWS Region, and Acres.
4. Describe the following physical attributes of the site:

   A. Unit Area: _____ ac Upland Area: _____ ac Native Sod Upland Area: _____ ac

   B. Dominant Soil Type (across the native sod portion of the management unit): We offer only general descriptions of soil type because soil definitions vary widely by state. Please select the best fit. If necessary, it is acceptable to select multiple soil types. For example, if the dominant range type is categorized as "loamy overflow", select Loamy and Overflow. For many, this data will be available through your private lands biologist. Alternatively, this information can be accessed online via NRCS' Web Soil Survey: http://tinyurl.com/NRCS-Web-Soil-Survey

   ☐ Clayey ☐ Sandy ☐ Overflow
   ☐ Loamy ☐ Silty ☐ Unknown

   C. Physiographic Region:

   ☐ Missouri Coteau ☐ Prairie Coteau
   ☐ Glaciated Plains ☐ Lake Dakota Plain
   ☐ Red River Valley/Lowlands ☐ James River Lowlands
   ☐ Coteau Slope ☐ Turtle Mountains
   ☐ North Central Glaciated Plains (MN) ☐ Lake Agassiz Aspen Parklands (N. MN)
   ☐ Glaciated Northern Grasslands (N MT) ☐ Glaciated Dark Brown Prairie (NE MT)
   ☐ N. Central Brown Glaciated Plains (MT) ☐ Unknown
   ☐ Other: _____

5. What is the classified grass type of the unit? ☐ Mixed-Grass ☐ Tallgrass

6. Estimate the vegetative composition of the native sod portion of this unit, excluding wetland or wet meadow areas (if available, use actual survey data to determine values):

Dominated by native herbaceous species:		%
Dominated by smooth brome:		%
Dominated by Kentucky bluegrass:		%
Dominated by woody species (native or non-native):		%
None of the above:		%
TOTAL:	**100 %**	

7. When was this unit acquired by the USFWS?

8. What was the unit's most recent land use under previous ownership?

☐ Pasture ☐ Hayland ☐ Idle/CRP ☐ Other (Describe Below) ☐ Unknown

Comments:

9. Provide a summary of the unit's management history while under USFWS ownership for each management year indicated. **The management year is September 1 - August 31**. For example, management year 2012 is the period September 1 2011 - August 31 2012. Check all boxes that apply within the given management year. A unit that did not receive one of the listed defoliation treatments (i.e., Burn, Graze, Hay, or Mow) is considered a "Rest". If the management for a particular year is not known, be sure to check the box for "Unknown". Provide comments as desired.

2012: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

2011: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

2010: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

2009: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

2008: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

2007: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

2006: ☐ Burn ☐ Graze ☐ Hay ☐ Mow ☐ Rest ☐ Other (describe) ☐ Unknown

Comments:

10. **Management Limitations:** Please identify any limitations that preclude implementation of particular management actions on the management unit by checking the appropriate box below. Please use the space provided to elaborate as to the reason for the limitation (e.g., cannot graze because do not have a water source on the unit for the animals). Also, please note whether the management restriction is expected to be permanent or whether circumstances may change in future management years. Please elaborate on your response in the space provided (e.g., do not currently have fencing to graze, but plan to add a fence next year). Be aware that units with management limitations that prevent application of one or more of the potential management action alternatives may not be appropriate for inclusion in the NPAM project; the Project Coordinator will review all units and will contact you if the unit is not deemed appropriate.

☐ No Management Limitations ☐ Cannot Graze ☐ Cannot Burn

Reason:

Is the limitation permanent? ☐ Yes ☐ No

If 'No', Why?:

PEER-REVIEWED STUDY

Monitoring Native Prairie Vegetation: The Belt Transect Method

by Todd A. Grant, Elizabeth M. Madden, Robert K. Murphy, Karen A. Smith and Melvin P. Nenneman

Belt transect method provides a quick, yet reliable, way to measure and monitor larger expanses of grassland habitat.

North American prairies continue to decline in quantity and quality because of conversion to other land uses, proliferation of woody vegetation, and invasion by exotic plant species (Samson and Knopf 1994, Bragg and Steuter 1995). Appropriate stewardship of remaining prairies is increasingly critical to preserving their native biodiversity (Ryan 1990, Samson and Knopf 1996). To successfully restore and maintain the ecological integrity of native prairies, restorationists must periodically assess local plant composition to detect vegetation problems (for example, invasive exotic species), help plan management treatments (for example, prescribed fire and grazing), and evaluate results of restoration efforts. Decisions by conservation agencies and organizations to acquire extensive prairie tracts may rest on rapid, yet reliable, assessments of the composition of extant plant communities. Moreover, plant community composition significantly influences the distribution, abundance, and reproduction of native prairie wildlife (Davis and others 1999, Madden and others 2000). The ability to quantify these relationships can help restorationists predict wildlife responses to prairie management.

Depending on scale and objectives, the composition of plant species or species groups may be quantified using any of various techniques that assess their frequency of occurrence, percent cover, or density (Elzinga and others 1998). Canopy-cover-age estimations (Daubenmire 1959) are often used to measure composition in herbaceous plant communities. Other methods may assess the occurrence of certain individual species and the degree to which those species reflect nondegraded conditions (Swink and Wilhelm 1994, Rooney and Rogers 2002). However, we have found these and other species-level methods ill-suited for broadly addressing fundamental questions of interest to restorationists of the northern mixed-grass prairie. These basic restoration questions seldom require species-level identification. They focus instead on the extent of woody and herbaceous vegetation types, and especially on the amount of native and exotic vegetation.

Relatively unintensive assessment methods that can be applied extensively and efficiently are needed for addressing basic prairie restoration issues in the context and scale of this region. Northern mixed-grass prairies set aside for conservation purposes are relatively extensive and remote, while persons charged with their stewardship are scarce. For example, a typical land manager in the U.S. Fish & Wildlife Service's National Wildlife Refuge System in North Dakota is almost solely responsible for conserving 10,000-50,000 acres (4,000-20,000 ha) of mixed prairie-wetland habitat, which often occurs as scores of tracts scattered widely over several counties. Moreover, the prairies typically need frequent, carefully

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timed defoliation by various tools (for example, six-year fire return interval [Bragg 1995]). As such, basic vegetation integrity on individual tracts should be assessed frequently, perhaps every three to five years, to support informed restoration decisions. Finally, species-level classification requires the ability to identify herbaceous plants in a vegetative (sterile) state. Few restorationists have adequate plant taxonomy skills required to document plant composition at this level, and misidentification of difficult taxa can make interpretation of results meaningless (Rooney and Rogers 2002).

Our method is not intended to supplant other assessment techniques, but rather to augment the selection of available tools used to quantify floristics of prairies that vary in degree of integrity and in basic issues of restoration. We contend that persons tasked with the challenge of conserving northern mixed-grass prairies must plan and proceed with restoration in the absence of data for all plant species on all areas. Instead, they need a method that 1) will reliably convey the status and trends of certain plant species and species groups of special management interest; 2) can be applied quickly, efficiently, and extensively; 3) is robust to varied observer skill levels; and 4) helps support development and application of models that describe wildlife-habitat relationships. Herein we describe application of a method that, in our experience, satisfies these needs while offering flexibility for use in a wide variety of grassland research and monitoring activities.

The Belt Transect Method: Its Development and Application

Working in northwestern North Dakota, Madden and colleagues (2000) categorized the dominant plant cover in 3-ft (1-m) diameter, circular quadrats according to broad groups of plant species or life forms. This method provided data useful for making management decisions and was reasonably robust to observer skill level, but was inefficient due to time required to locate and place quadrats. On remnant grasslands in Maine, Vickery and others (1994) used a modified line transect (Canfield 1941) to assess the cover of general plant groups (described mostly by life form) on 328-ft (100-m) radius grassland plots where bird species occurrence was also determined. We modified the line transect method described by Vickery and others (1994) to include a 0.3-ft (0.1-m) wide "belt" (rather than a line) to classify vegetation.

To employ the belt transect method, we stretch a measuring tape across the vegetation to the desired transect length and identify the dominant plant group present (Appendix A) at each 0.3-ft x 1.5-ft (0.1-m x 0.5-m) segment along the tape. (Standard metric tapes indexed at 0.5-m increments are available from Forestry Suppliers, Inc.) The investigator holds the tape loosely about 3 feet (1 m) above ground and walks steadily along it while looking down and classifying the plant group in each segment. The process is rapid because classes of vegetation often are similar among successive segments. The investigator must only note points on the meter tape at which the vegetation class changes, and the nature of the change. An assistant records the data. Initially, investigators may be slow to identify plant groups, but with practice and familiarity they can classify vegetation as quickly as they can walk along the tape and communicate data to an assistant (for example, with practice, a 328-ft [100-m] transect requires about five minutes to complete). In northern mixed-grass prairie, plant identification is facilitated when transects are completed during mid- to late summer when both cool- (C_3) and warm-season (C_4) plants are more easily recognized.

Transect length generally is governed by the application objective. When monitoring primarily vegetation condition or change (that is, over time or among treatments) we may use many 82-ft (25-m) transects placed randomly or placed in a stratified-random array based on aspect or range site. We often use transects within 150- to 300-ft (50- to 100-m) radius plots where we also measure wildlife abundance, so the data can support analyses of species-habitat relationships (Vickery and others 1994, Madden and others 2000). The results of belt transect data are summarized as percent occurrence or frequency of plant groupings within each transect or plot. To support assessments of species-habitat relationships, we may combine measures of vegetation structure, such as height-density (Robel and others 1970), vertical density (Wiens 1969), and litter depth recorded at 15- to 30-ft (5- to 10-m) intervals along each transect.

Derivation of Plant Groups

We classify vegetation according to a moderately detailed, hierarchical breakdown of plant groups (Appendix A). We derived plant groupings by using local and regional references that describe common native plant community associations for upland sites in northwestern North Dakota and surrounding areas (Hegstad 1973). We confine native herbaceous types to categories of moderate detail because 1) subtle shifts in species makeup among native grass-forb types occur continually due to precipitation patterns (Weaver 1968), 2) sampling efficiency and accuracy among investigators are compromised by increasing the complexity of classifications, and 3) our restoration work is mainly concerned with relatively few species of noxious, exotic, and otherwise invasive plants that compromise the integrity of extant native prairie tracts.

We also include commonly occurring associations of intermingled native and exotic vegetation, as well as woody types encountered (Appendix A). Our specific area of interest is northeastern Montana to north-central North Dakota. Some details of our plant group lists vary slightly across this area depending especially on local vegetation patterns and relevant management issues. However, by collapsing moderately detailed plant groups into similar, general categories (for example, by life form; Figure 1), we can readily communicate and exchange data across this landscape.

The belt transect sampling method is flexible and can be applied in grasslands outside of our area of interest, providing that the classification of plant groups is derived from local sources (for example,

published and unpublished data, herbarium collections, and so on). The plant groups we use translate (or "cross-walk") into those of the National Vegetation Classification System (NVCS, Grossman and others 1998), the hierarchical standard recently adopted by most federal resource management agencies. Although NVCS considers natural and semi-natural (or altered) vegetation, we more explicitly delineate exotic plant groups because they are a primary threat to the integrity of native prairie in the region.

Examples of Applications

Prairie Inventory and Restoration

Lostwood National Wildlife Refuge (LNWR) is 27,000 acres (10,800 ha) of rolling to hilly, mixed-grass prairie interspersed with about 4,000 wetland basins in northwestern North Dakota. Encroachment by woody vegetation and exotic grasses, especially smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*), is the main prairie restoration issue at LNWR. During August 2000 we used belt transects to document the plant community makeup on two prairie tracts on LNWR. The first is a 1,200-acre (500-ha) tract that had been managed by rest and occasional light grazing, but without fire since the early 1900s. The other, a 1,280-acre (518-ha) tract, was located nearby and had similar soils, topography, and management history, except that it had been prescribed burned during August in 1990, 1992, and 1994.

We recorded plant group makeup on 72 82-ft (25-m) transects on the unburned tract and 54 transects on the burned tract. Transects were stratified by three common site types: 1) xeric, 2) north- to east-facing (NE) slope, and 3) south- to west-facing (SW) slope. We centered each transect across the respective site and placed NE and SW transects perpendicular to the slope. We permanently marked the end points of each transect in the field and recorded these with a global positioning system (GPS) to facilitate relocation for long-term assessment.

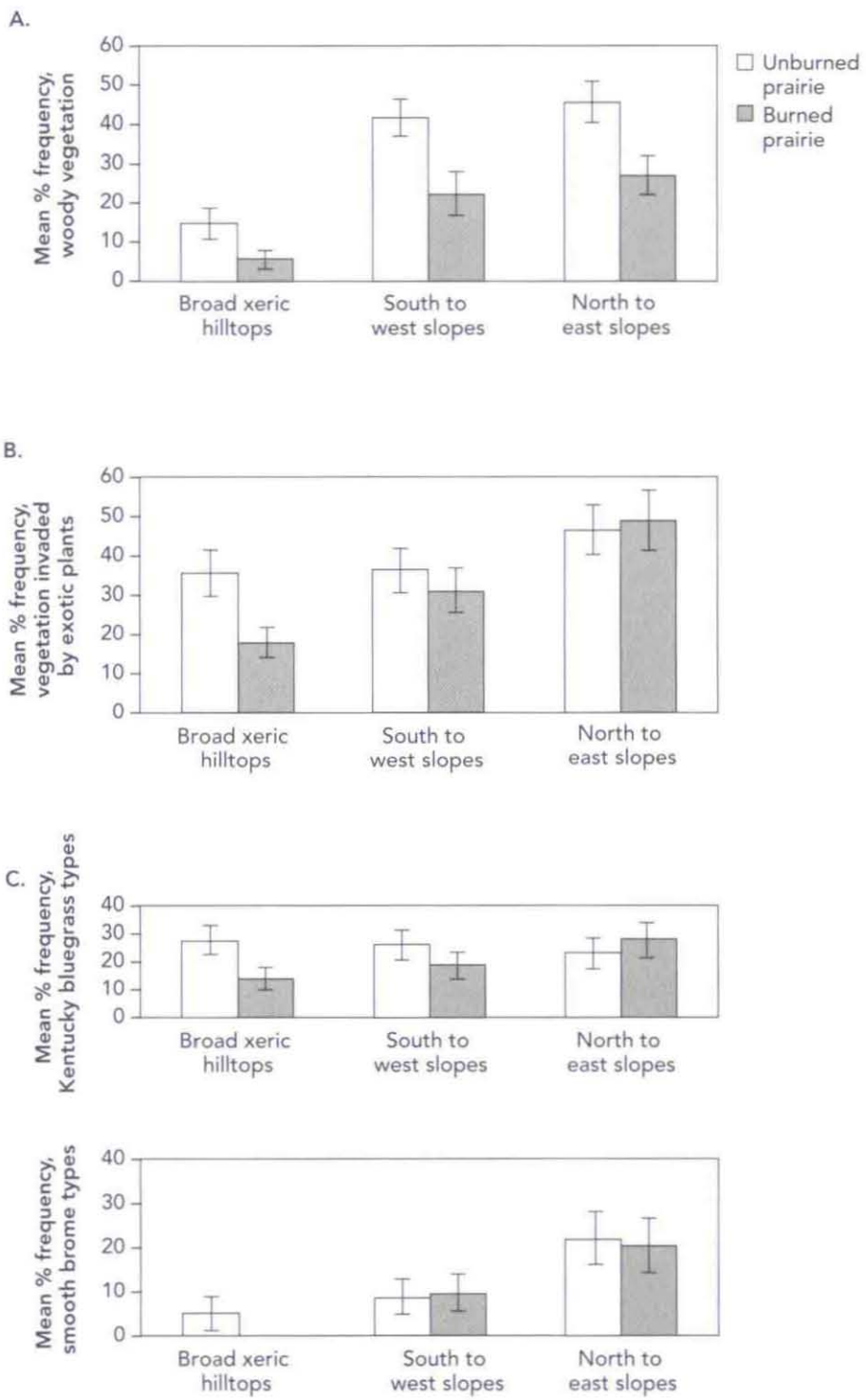

Figure 1. Occurrence of vegetation of special management interest on a 1,200-acre (500-ha), mixed-grass prairie tract managed by prescribed burning, and on a nearby, 1,280-acre (518-ha), unburned prairie tract at Lostwood National Wildlife Refuge, North Dakota, based on belt transect sampling during August 2000: A. woody vegetation. B. vegetation invaded by exotic plant species. C. vegetation invaded by Kentucky bluegrass and by smooth brome. On each tract, 25-m transects were located in three topographic site types: xeric, south to west slope, and north to east slope (n = 25 transects in each site type in the unburned tract and n = 18 in each in the burned tract; vertical bars represent standard errors).

Using hierarchical plant groupings described for the region (Appendix A), the transects yielded data that support general to detailed summaries depending on the restoration issues of interest. A view based on broad life form groups indicates woody-dominated vegetation is prevalent on SW and NE sites and occurs more frequently on unburned prairie than on burned prairie (Figure 1A). Principal woody plant species are low shrubs—western snowberry (*Symphoricarpos occidentalis*) and silverberry (*Elaeagnus commutata*) (Appendix A). Another generalized view indicates that exotic plant species exist on all sites, but on xeric sites, they occur more frequently on unburned prairie than burned prairie (Figure 1B). A closer look (Figure 1C) indicates that Kentucky bluegrass is the main exotic plant species of concern on xeric sites, but it apparently decreases with repeated summer burning. By contrast, smooth brome rarely occurs on xeric sites, although it may also decrease on such sites with burning. Kentucky bluegrass also appears more important than brome on the relatively warm, dry south and west slopes.

A restorationist at LNWR might revise their treatment strategies to more effectively target smooth brome, particularly on xeric sites, while continuing to discourage Kentucky bluegrass. Elsewhere, another restorationist might similarly consider the shift in balance between native cool- and warm-season grass-forb types (Types 41 and 42, Appendix A) in response to management. Long-term trends that reflect specific restoration practices and/or fluctuating climatic conditions can be assessed using repeated measurements of permanently established transects.

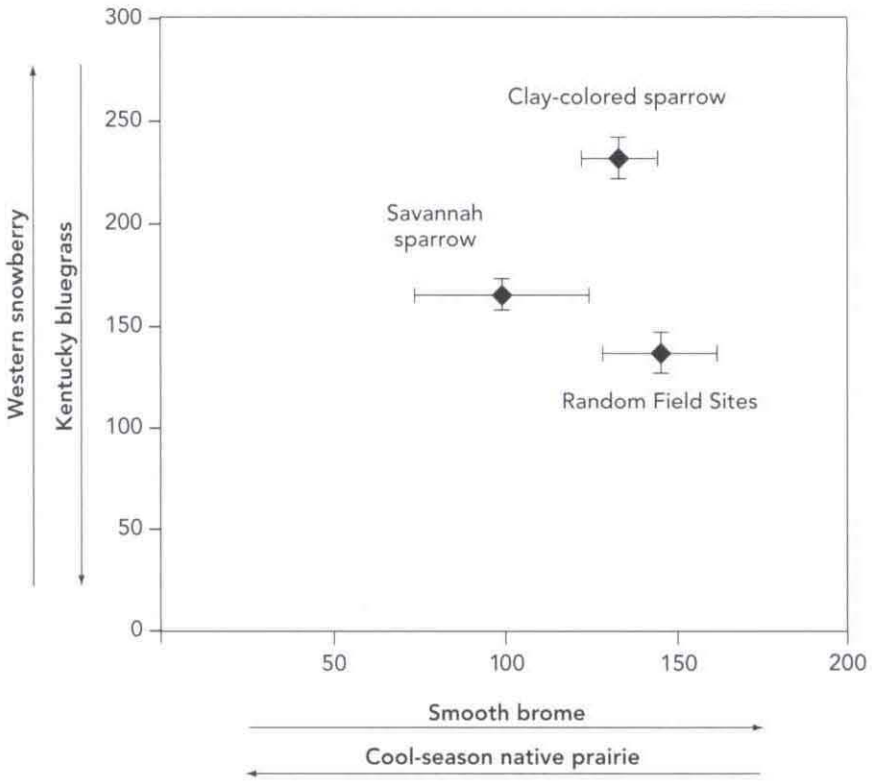

Figure 2. Belt transect data collected in north-central North Dakota in 1999 provided vegetation frequency readings from nest sites of clay-colored sparrow (n = 37) and savannah sparrow (n = 44), and random field sites (n = 104). Axes represent relative changes in vegetation frequency among four vegetation groups with arrow direction representing increasing coverage for each group. Each centroid represents the mean and 95 percent confidence interval for its respective axes.

Nest Site Selection by Grassland Birds

In 1999, we described the vegetation composition at the nest sites of grassland birds on J. Clark Salyer National Wildlife Refuge in north-central North Dakota. We used 15-ft (5-m) transects centered on each nest. A transect was established along a random compass bearing and subsequent transects were placed at 90, 180, and 270 degrees from this first. Each 15-ft (5-m) radius plot yielded 40 belt segments. Seasonal technicians gradually became familiar with the vegetation of the region while conducting other field work in June and July. Just prior to data collection, one of us (Grant) spent about two days training crews to 1) identify about 50 plant species most characteristic of the area, 2) recognize the major plant groupings used for our region (Appendix A), and 3) use the belt transect method to quantify vegetation composition. Once trained, a crew could travel to sites, locate nests in the field, and complete data collection for about 80-120 nests per day.

We summarized transect data as frequency of occurrence with data lumped into broad, hierarchical plant groupings. We then used these data to compare the plant composition at a species' nest site to that among randomly placed plots (to determine nest site selection), or to the nest sites of other species (to determine niche selection). We found that clay-colored sparrow (*Spizella pallida*) selected nest sites with greater relative coverage of western snowberry (Figure 2). Savannah sparrow (*Passerculus sandwichensis*) appeared to prefer nest sites with greater relative coverage of native grasses, and to avoid sites dominated by smooth brome. Furthermore, the two species appear to partition nesting habitat based, in part, on the relative occurrence of western snowberry and Kentucky bluegrass (Figure 2).

A Test of Objectivity

Accuracy of a given vegetation sampling technique is almost always assumed but rarely tested. In 1995, we used fixed radius point counts (Hutto and others 1986) to survey avian occurrence on 300-ft (100-m) radius plots within 28,000 acres (12,000 ha) of aspen (*Populus tremuloides*) parkland in north-central North Dakota. We used the accompanying vegetation data to test the accuracy of the belt transect method to

estimate relative occurrence of aspen woodland. We chose aspen woodland because it was readily identified on aerial photos and could be accurately mapped. Also, the clonal nature of aspen enabled us to evaluate the accuracy of belt transects for measuring patchy, often widely scattered plant groups.

We located plot centers in the field (within ±10 ft) by using a GPS. Using ArcView®, we circumscribed each point with a 300-ft (100-m) radius circle and then overlaid each plot on 1:7920 digital orthoquadrangle photos (3-ft mapping resolution). We digitized all aspen clones (plant groups 31 and 32; Appendix A) that occurred within each 100-m radius plot as a GIS coverage. We then calculated the percent area of aspen cover within each plot. This provided an unbiased, direct measure of percent aspen cover to which we could compare data collected with the belt transect method. We then used four 100-m belt transects to measure plant community composition within each plot (Vickery and others 1994). Beginning at a plot center, we first established a transect along a random compass bearing and then placed subsequent transects at 90, 180, and 270 degrees from this first. We classified vegetation according to methods described above, with each plot yielding 800 belt segment records. Using two observers and two data recorders, we completed each plot in about 20 minutes. To correct for an area bias due to over-sampling the center of each plot, we systematically omitted 1.5-ft (0.5-m) segment data within each of ten 10-m bands extending from the plot center, such that the remaining 421 segments were proportionally distributed according to the area within each band (using a computer spreadsheet, omissions were done following data collection).

Using 76 plots, we found that frequency data collected using the belt transect method accurately reflected actual aspen woodland coverage, although aspen cover was slightly over- or under-represented in some cases (Figure 3). Because the true frequency of a given plant group is seldom known, our comparison lends confidence to the use of belt transects, within the constraints of sound sampling procedures, to estimate relative frequency of plant groups.

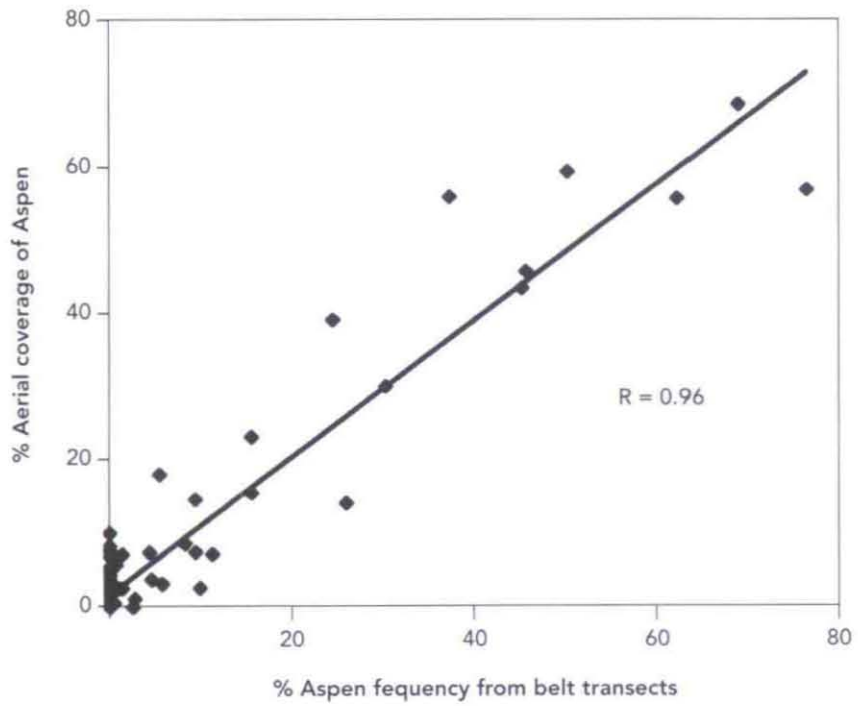

Figure 3. Correlation between the percent frequency of invasive aspen woodland measured with the belt transect method and the actual aspen woodland cover derived from 1:7920 aerial photos. Data were collected from 76 328-ft (100-m) radius plots in north-central North Dakota in 1995.

Conclusion

In summary, we describe a belt transect technique that can be used to document the status and trend of certain plant species and species groups of particular management interest across the northern mixed-grass prairie and other regions where restorationists are scarce, but prairies and the need for prairie restoration are not. The belt transect method can be applied quickly, efficiently, and extensively, is robust to varied observer skill levels, and supports the development of wildlife-habitat models. This method appears to offer wide flexibility for restorationists who must periodically assess plant community composition, detect vegetation problems, plan management treatments, and evaluate results of restoration efforts.

Acknowledgments

This technique was developed over several years in cooperation with managers and biologists within the U.S. Fish & Wildlife Service. Gary Erickson was particularly instrumental in field testing earlier versions of this method. Chuck Loesch and Rachel Diebboll helped us crosswalk vegetation categories into the NVCS. Paul Bultsma, Rachel Diebboll, Cathy Jean, Al Steuter, and two anonymous reviewers graciously reviewed the manuscript.

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Appendix A. Example of hierarchical listing of upland plant group types for north-central and northwestern North Dakota. One of the below types is recorded for each 0.3 x 1.5-ft (0.1 x 0.5-m) segment along an outstretched measuring tape, based on greater than 50 percent dominance by canopy cover unless otherwise indicated.

Shrub and tree types

low shrub (generally less than or equal to 5 ft [1.5 m] tall, except in one to few post-disturbance years)

11 snowberry dense (other low shrub spp. total 0-25 percent); other plants few or none
12 snowberry (and other low shrub spp.); remainder mostly native grass-forb types
13 snowberry (and other low shrub spp.); remainder mostly Kentucky bluegrass
14 snowberry (and other low shrub spp.); remainder mostly smooth brome (or quackgrass)
15 silverberry prominent, remainder mostly native or invaded native grass-forbs
16 silverberry prominent; remainder mostly Kentucky bluegrass
17 silverberry prominent; remainder mostly smooth brome (or quackgrass)

tall shrub (generally 5 to 16 ft [1.5 to 3 m] tall) or tree (greater than 16 ft tall)

21 chokecherry, Juneberry, hawthorn, willow, dogwood
22 shrub-stage aspen
23 exotic shrub: caragana, honeysuckle, russian olive, etc.
31 aspen tree
32 burned-over aspen tree (dead or dying post-fire snags)
33 shade-tolerant woodland tree: green ash, box elder, elm

Native grass and forb types *Greater than 95 percent dominance by native herbaceous plants**

41 dry cool season (sedges, green needlegrass, needle-and-thread, wheatgrass spp., prairie Junegrass, forbs; often blue grama and some other C_4 species)
42 dry warm season (little bluestem, prairie sandreed, plains muhly, fescue spp., blue grama, forbs)
43 mesic warm-cool mix (big bluestem, switchgrass, little bluestem, porcupine grass; mat muhly, prairie dropseed, forbs)
46 subirrigated wet meadow microsite within upland (fowl bluegrass, foxtail barley, northern reedgrass, coarse sedge spp., Baltic rush, dock, prairie cordgrass)
47 cactus
48 clubmoss

Exotic and invaded native grass-forb types

51 Kentucky bluegrass greater than 95 percent
52 Kentucky bluegrass and native grass-forbs, bluegrass 50-95 percent
53 native grass-forbs and Kentucky bluegrass, bluegrass 5-50 percent
61 smooth brome (or quackgrass) greater than 95 percent
62 smooth brome (or quackgrass) and native grass-forbs, brome 50-95 percent
63 native grass-forbs and smooth brome (or quackgrass), brome 5-50 percent
71 crested wheatgrass greater than 95 percent
72 crested wheatgrass and native grass-forbs, crested wheatgrass 50-95 percent
73 native grass-forbs and crested wheatgrass, crested wheatgrass 5-50 percent
78 tall, intermediate, or pubescent wheatgrass

Noxious weed types

81 leafy spurge
85 Canada thistle
88 other noxious weeds (user-defined)

Other

91 barren, unvegetated (for example, rock, anthill, bare soil)
98 tall exotic legume: sweet clover or alfalfa
00 wetland basin: temporary, seasonal, or semipermanent wetland (Stewart and Kantrud 1971)

*Prairie rose is considered a native forb in this classification.

North Dakota Upland Plant Associations Updated June 26, 2009 (Modified from Grant et. al 2004)

Record 1 of the below codes per 0.5 meter segment, based on **dominant canopy cover**

SHRUB and TREE TYPES

low shrub (generally <1.5m tall)

11 snowberry dense; other plants few or none
12 snowberry; remainder mostly NATIVE grass-forb types
13 snowberry; remainder mostly Kentucky bluegrass
14 snowberry; remainder mostly smooth brome (or quackgrass)
16 snowberry; remainder mostly crested wheatgrass
15 silverberry; add modifier 15[2] = NATIVE grass-forb, 15[3] = KY bluegrass, 15[4] = brome (or quack), 15[5] = crested
18 meadowsweet; add modifier as above 18[2], 18[3], or 18[4], 18[5] = crested
19 other low shrub (user defined – add modifier)

tall shrub/tree (generally ≥1.5m tall)

21 native shrub (chokecherry, buffaloberry, hawthorn, willow)
22 shrub-stage aspen
23 introduced shrub (caraganna, Russian olive)
31 aspen
33 shade-tolerant woodland tree (green ash, box elder, American elm)
34 oak
35 introduced tree (Siberian elm, Juniper, spruce)

NATIVE GRASS-FORB and FORB TYPES (>95% dominance by native herbaceous plants, including forbs)a, b

41 dry cool season (sedges, green needlegrass, needle-and-thread, wheatgrass spp., prairie junegrass, forbs)
42 dry warm season (little bluestem, prairie sandreed, blue gramma, frobs)
43 mesic cool-warm mix (big bluestem, switchgrass, porcupine grass, prairie dropseed, forbs)
46 meadow (fowl bluegrass, foxtail barley, northern reedgrass, fine-stem sedge spp., baltic rush, cordgrass).
47 wetland; robust emergent vegetation or open water (cattail, river bulrush, bur-reed, phragmites, manna grass)
48 clubmoss/lichen
49 forb

INTRODUCED and NATIVE GRASS-FORB TYPES a

51 Kentucky bluegrass >95% (or >50% if mixed with other non-natives)
52 Kentucky bluegrass and NATIVE grass-forbs, KY bluegrass 50-95%
53 NATIVE grass-forbs and Kentucky bluegrass, KY bluegrass 5-50%

61 smooth brome >95% (or >50% if mixed with other non-natives)
62 smooth brome and NATIVE grass-forbs, brome 50-95%
63 NATIVE grass-forbs and smooth brome, brome 5-50%

71 crested wheatgrass >95% (or >50% if mixed with other non-natives)
72 crested wheatgrass and NATIVE grass-forbs, crested wheatgrass 50-95%
73 NATIVE grass-forbs and crested wheatgrass, crested wheatgrass 5-50%

74 quackgrass >95% (or >50% if mixed with other non-natives)
75 quackgrass and NATIVE grass-forbs, quackgrass 50-95%
76 NATIVE grass-forbs and quackgrass, quackgrass 5-50%

77 reed-canary grass
78 tall, intermediate, or pubescent wheatgrass
79 other introduced grass (user defined)

INTRODUCED WEED TYPES

81 leafy spruge
85 Canada thistle
87 wormwood
88 other introduced weeds (user-defined)
98 tall introduced legume: sweet clover of alfalfa

OTHER

91 barren/unvegetated (e.g., rock, anthill, bare soil); dead vegetation
99 other – user defined

[a]Prairie rose, bearberry, winterfat, and cactus are considered a native forbs with respect to these categories.
in the event of an apparent equal mix of KY bluegrass and smooth brome – consider as code **61, 62

South Dakota Upland Plant Associations

Updated: July 27, 2009

- Record 1 of below types
- Based on Daubenmire dominant canopy cover
- These categories are designed for monitoring plant community composition of native sod, planted natives, and DNC.
- Revised from Grant et al. 2004, Hegstad 1973.
- Document robust patches of native forbs >50% with category 25 (i.e., lead plant, goldenrod, etc.). Alternatively, category 75 (other weeds) can be used to document weed patches that typically dominate disturbed sites.
- Litter is not a category in itself, therefore assign litter to category it applies to (e.g., Kentucky bluegrass litter = 31).
- In the event of an apparent equal mix of KY bluegrass and smooth brome – consider as code 41.
- Prairie rose and leadplant are considered native forbs with respect to these categories.

SHRUB & TREE TYPES

Low shrub (generally 0.5 to 1.5 m tall, e.g. western snowberry)

11 dense low shrub, other plants few or none
12 low shrub, remainder native grass and forb
13 low shrub, remainder KY bluegrass
14 low shrub, remainder brome or quackgrass
19 low shrub, remainder crested

Tall shrub (generally 1.5 to 5 m tall)

15 tall shrub, native
16 tall shrub, exotic

Trees

17 native trees (e.g. cottonwood, green ash, bur oak)
18 non-native trees (e.g. Japanese elm, Russian olive)

NATIVE GRASS-FORB TYPES[a]

21 cool season grasses & forbs A) green needle, B) western wheatgrass, C) porcupine grass
22 warm season grasses & forbs A) big bluestem, B) switch, C) Indian, D) little bluestem
23 meadow (sedges, baltic rush, dock, smartweed, cordgrass, reedgrass, horsetail, foxtail barley, etc.)
24 wetland; robust emergent vegetation or open water (cattail, river bulrush, bur-reed, Phragmites, manna grass)
25 forb

INTRODUCED, INVASIVE, OR PLANTS OF MANAGEMENT CONCERN

31 Kentucky bluegrass dominant
41 smooth brome dominant
51 crested wheatgrass dominant
52 quackgrass
53 reed-canary grass

61 tall, intermediate, or pubescent wheatgrass
62 other non-native grass – user defined (downy/Japanese brome, etc.)

NOXIOUS & OTHER WEED TYPES

71 leafy spurge
72 canada thistle
73 sow thistle
74 wormwood
75 other weeds (kochia, ragweed, cocklebur, etc.)
76 other noxious weed (user-defined)

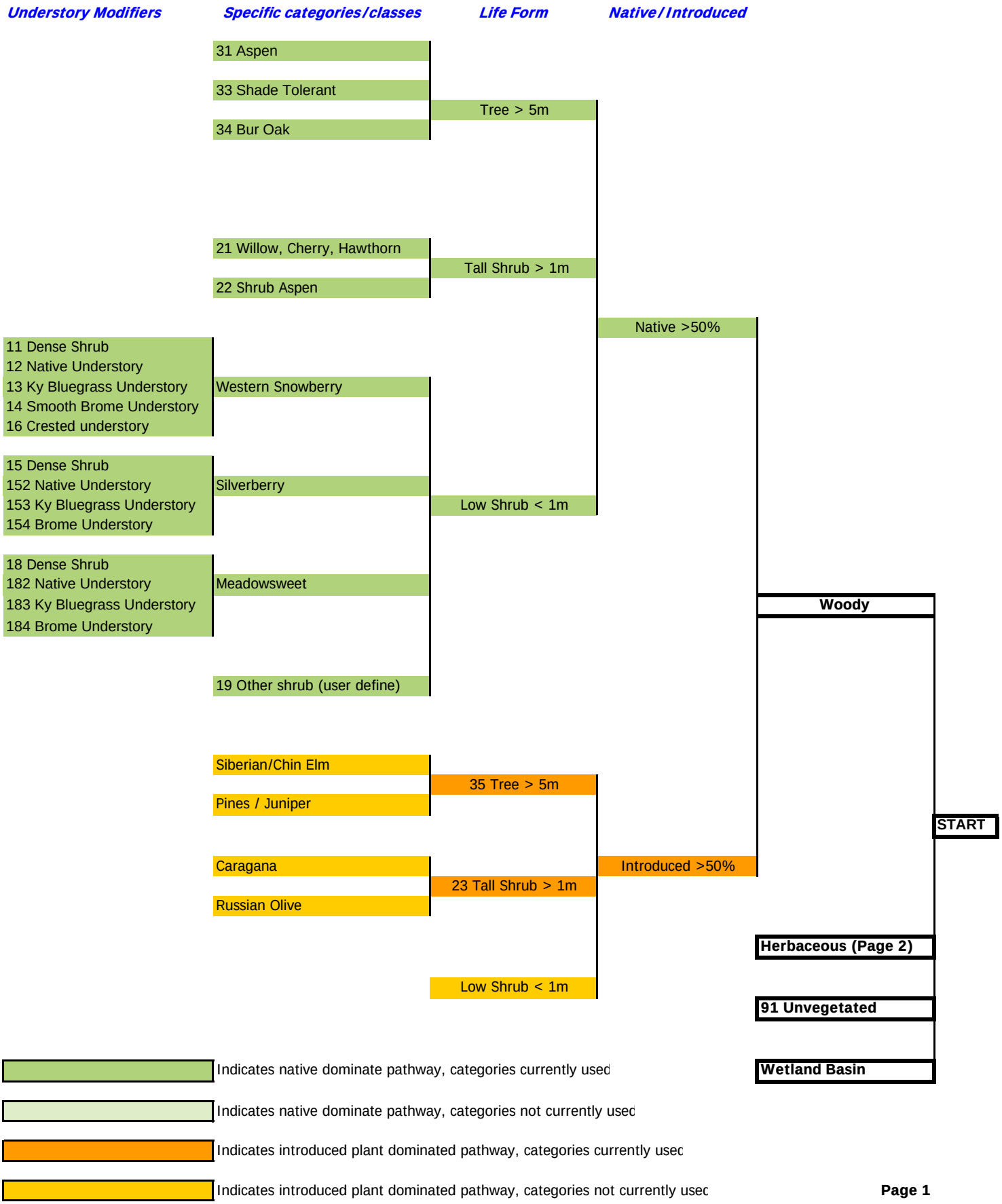
OTHER

81 tall introduced legume (sweet clover or alfalfa)
83 cactus
84 clubmoss/Lichen

91 barren, unvegetated (bare soil, gopher mound)
92 other (rock, manure, hole, ant hill)

[a]*Optional* Species Modifier: Document dominant native grass sp. using the respective letter

Classification Tree for North Dakota Belt Transects



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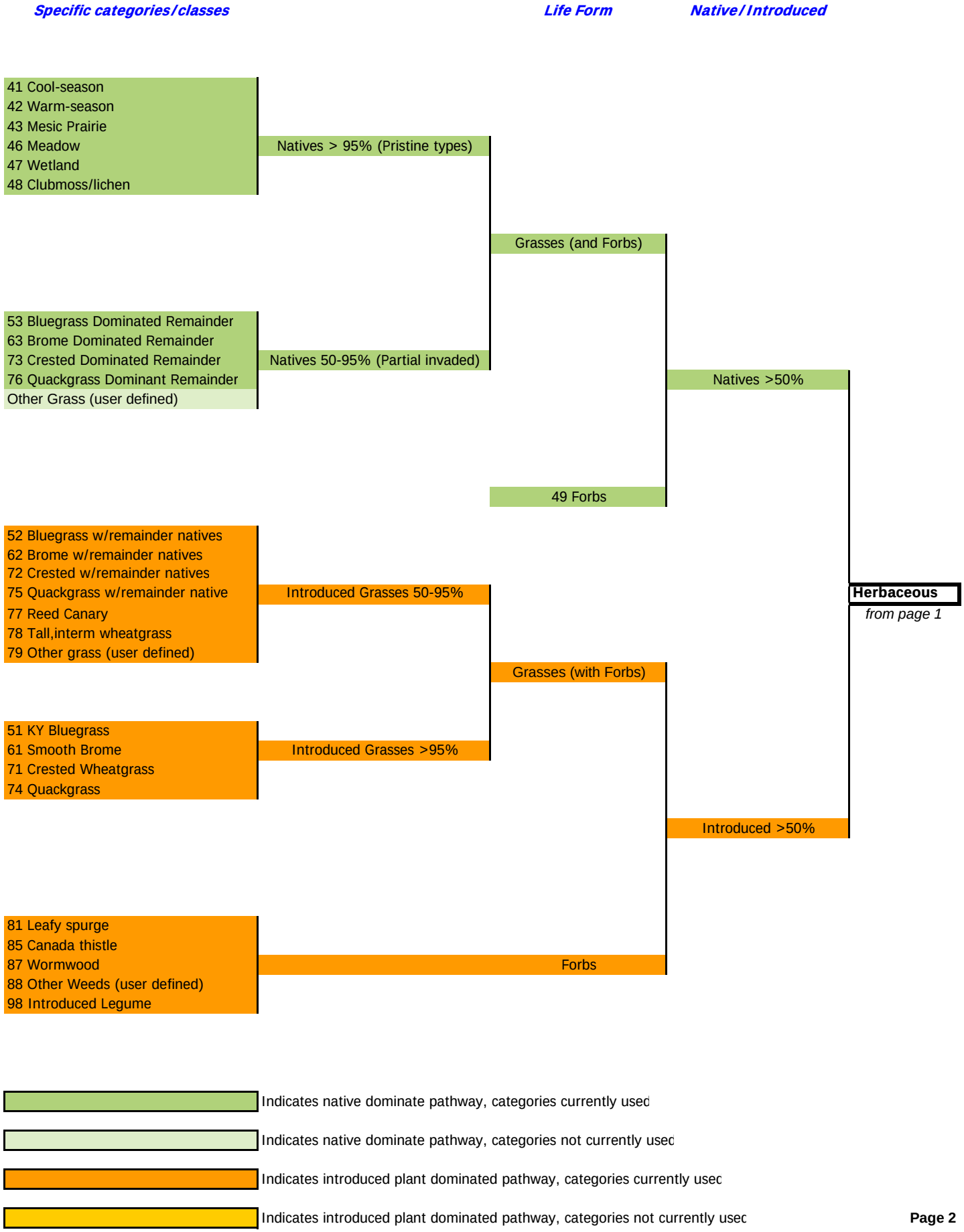
Classification Tree for North Dakota Belt Transects



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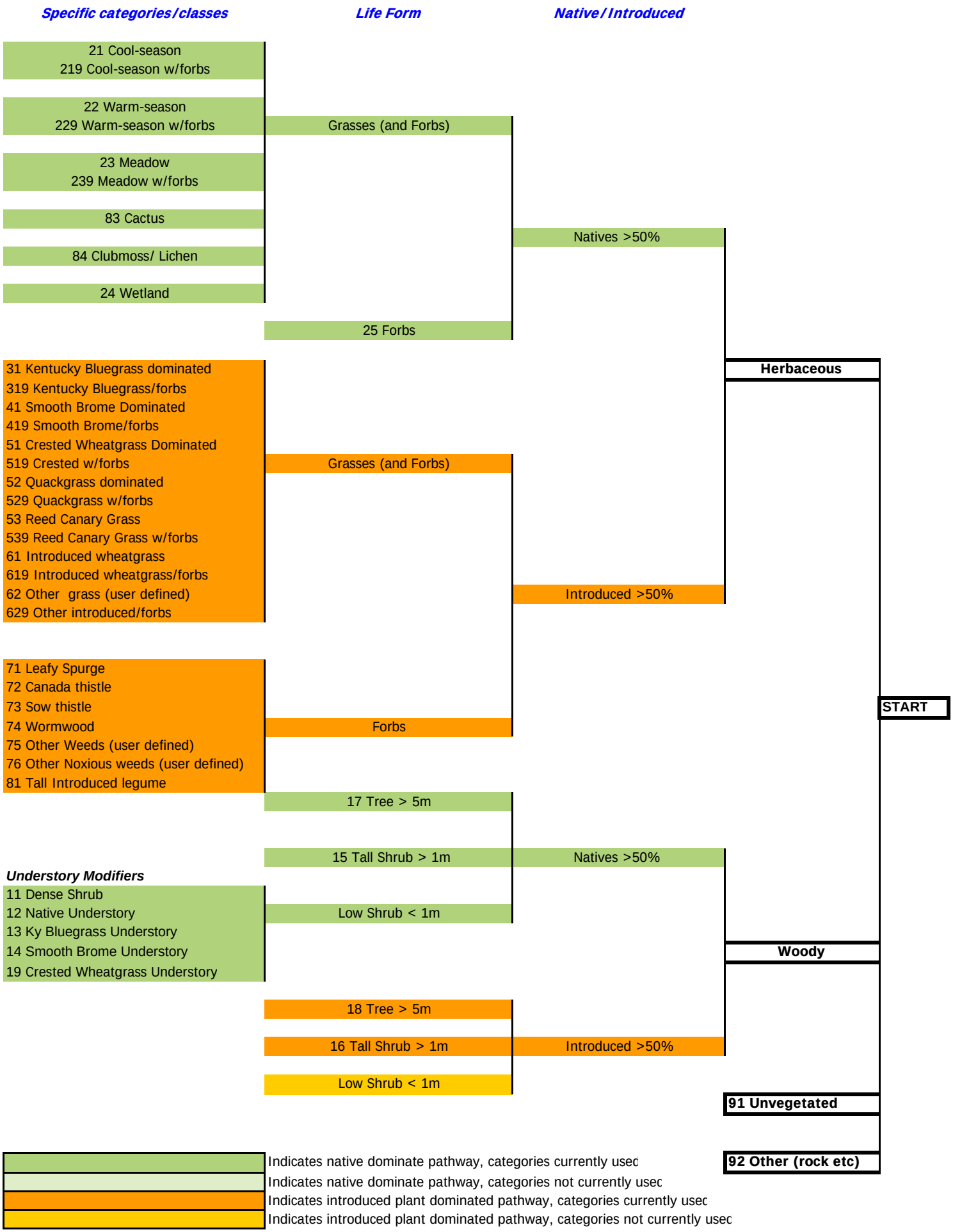
Classification Tree for South Dakota Belt Transects



APPENDIX H: VEGETATION FIELD MONIOTORING DATASHEET

Plot		Plot		Plot		Plot	
Point		Point		Point		Point	
Date		Date		Date		Date	
Observer		Observer		Observer		Observer	
Aspect		Aspect		Aspect		Aspect	
Slope		Slope		Slope		Slope	
Bering		Bering		Bering		Bering	

0.5		0.5		0.5		0.5	
1		1		1		1	
1.5		1.5		1.5		1.5	
2		2		2		2	
2.5		2.5		2.5		2.5	
3		3		3		3	
3.5		3.5		3.5		3.5	
4		4		4		4	
4.5		4.5		4.5		4.5	
5		5		5		5	
5.5		5.5		5.5		5.5	
6		6		6		6	
6.5		6.5		6.5		6.5	
7		7		7		7	
7.5		7.5		7.5		7.5	
8		8		8		8	
8.5		8.5		8.5		8.5	
9		9		9		9	
9.5		9.5		9.5		9.5	
10		10		10		10	
10.5		10.5		10.5		10.5	
11		11		11		11	
11.5		11.5		11.5		11.5	
12		12		12		12	
12.5		12.5		12.5		12.5	
13		13		13		13	
13.5		13.5		13.5		13.5	
14		14		14		14	
14.5		14.5		14.5		14.5	
15		15		15		15	
15.5		15.5		15.5		15.5	
16		16		16		16	
16.5		16.5		16.5		16.5	
17		17		17		17	
17.5		17.5		17.5		17.5	
18		18		18		18	
18.5		18.5		18.5		18.5	
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20.5		20.5		20.5		20.5	
21		21		21		21	
21.5		21.5		21.5		21.5	
22		22		22		22	
22.5		22.5		22.5		22.5	
23		23		23		23	
23.5		23.5		23.5		23.5	
24		24		24		24	
24.5		24.5		24.5		24.5	
25		25		25		25	

NPAM MANAGEMENT ACTIONS DATA SHEET

Management Unit _____ Management Year _____
(*note: management year is Sept 1 to Aug 31)*

Contact Name _____

Management type(s) that occurred during the management year (circle all that apply and complete appropriate section on following pages)		
Rest	Graze	Other/Special
Hay	Burn	

Comments (not management action-specific)

REST

Comments

NPAM Management Actions Data Sheet

HAY

Start Date		End Date	

Full management unit hayed?	If no, native sod upland acres hayed:
Yes No	
Rake used to remove litter?	Approximate stubble height (inches)
Yes No	

Comments

OTHER

Start Date		End Date	

Acres Treated	

Description

Management Unit_____ Management Year_____

NPAM Management Actions Data Sheet

GRAZE

Start Date		End Date	

Full management unit grazed?	If no, native sod upland acres grazed:
Yes No	

Number and type of grazing animals								
Number	Type	Animal Unit Equiv.	Number	Type	Animal Unit Equiv.	Number	Type	Animal Unit Equiv.
	Bull	1.5		Bison			Ewe/lamb pair	
	Cow/calf pair	1.2		Elk			Sheep (mature)	
	Cow			Horse/ mule			Nanny/kid pair	
	Yearling			Llama			Goat (mature)	
	Weined calf							

Stocking rate calculation

_____ x _____ x _____ ÷ 30 ÷ _____ = _____
number animal unit equiv. days grazed acres grazed AUMs/ac

Utilization (choose one)					
	Unused (0%)		Moderate (21-40%)		Close (61-80%)
	Slight (1-20%)		Full (41-60%)		Severe (81-100%)

Comments

Management Unit_____ Management Year_____

NPAM Management Actions Data Sheet

BURN

Start Date		End Date	

Full management unit burned?	If no, native sod upland acres burned:
Yes No	

Type of Fire
Prescribed Wildland

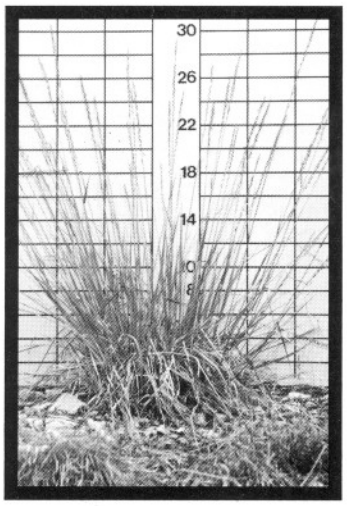
Burn Intensity (choose one)			
	Unburned		Moderately burned
	Scorched		Heavily burned
	Lightly burned		Not applicable

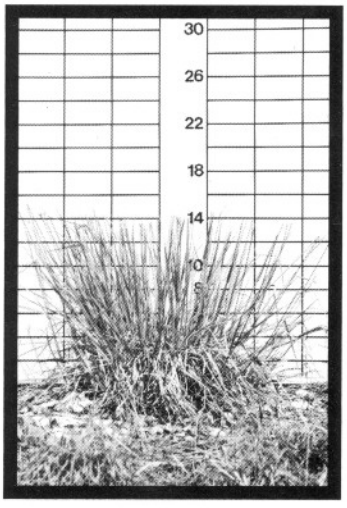
Fire Coverage (% of treated portion)				
0-10	20-30	40-50	60-70	80-90
10-20	30-40	50-60	70-80	90-100

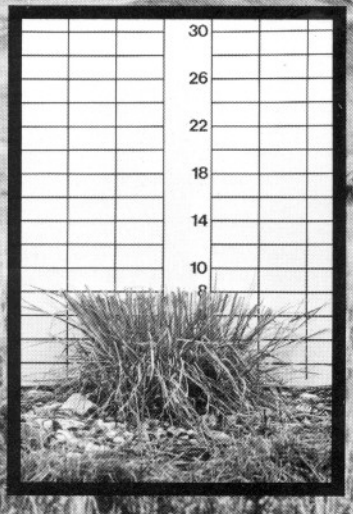
Comments

Management Unit_____ Management Year_____

ICS







EC 900
1994

Estimating GRASS Utilization Using Photographic Guides

Cooperative Extension Service / South Dakota State University / U.S. Department of Agriculture

EC 900
1994

Estimating GRASS Utilization Using Photographic Guides

by James R. Johnson,
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Stocking rate, and the resulting level of grass utilization (or grass weight removed) by grazing livestock, has more impact on grass productivity than any other single factor within the range manager's control. Determining the level of utilization for a pasture is one of the most important measurements that a manager can make when monitoring grazing management over years. The photo guides and procedures presented in this publication are intended to make grass utilization estimates both rapid and useful. The terms "utilization," "use," and "degree of use" all have similar meanings.

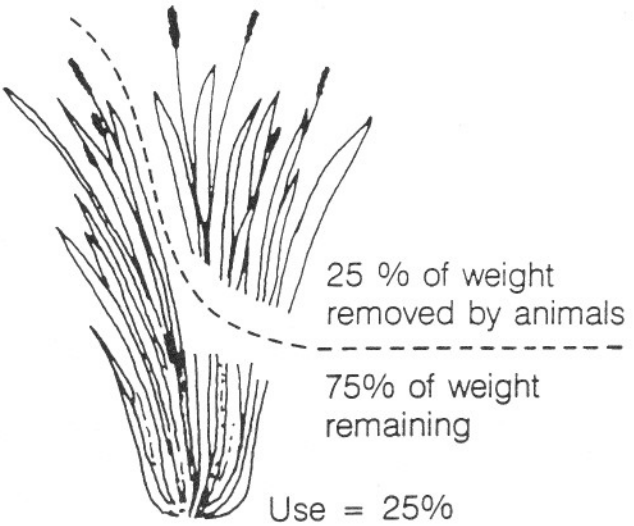
What Does Utilization Mean?

Utilization is the proportion of current year's forage production that is consumed and/or destroyed by grazing animals. Utilization may refer either to a single species or to all of the grazable vegetation of a pasture (Jacoby, 1989). Pasture utilization may be estimated based on the utilization of a single species or combinations of species for different range sites or different grazing seasons.

"Utilization," "use," or "degree of use" is expressed as a percentage of the total weight that is removed (Figure 1).

Utilization estimates can be made for grasses, forbs, or browse (shrubs), but are limited in this publication to estimates for grasses.

Figure 1. Forage use of a bunchgrass.

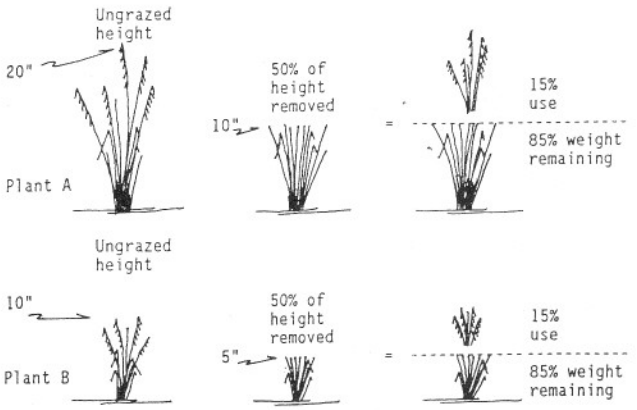


Height-Weight Relations in Grass

It's important to remember that **utilization refers to percent of weight removed, not to percent of height removed.** Plant height of a grass obviously will vary drastically from year to year or from location to location, but weight distribution from bottom to top of a grass is consistent. Most of the weight of a grass plant is concentrated nearer the bottom.

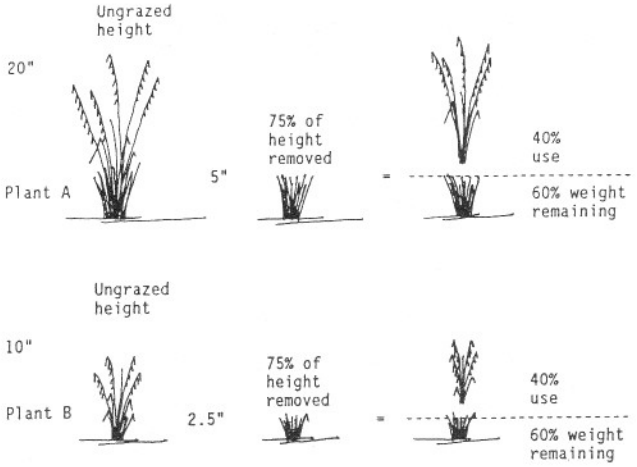
Figure 2 shows two different sideoats grama plants, both grazed to 50% of their original height. The percent weight removed is the same, 15%, when grazed to 50% of the ungrazed height.

Figure 2. Sideoats grama grazed to 50% of original height.



When these plants are grazed to 25% of their original height, percent weight removed is again the same for both (see Figure 3). In this example, 40% of the weight is removed when either plant is grazed to 25% of the ungrazed height.

Figure 3. Sideoats grama grazed to 25% of original height.



Why Determine Utilization?

Early researchers learned that the health and vigor of a grass plant (or a pasture) is not affected as much by the amount of height removed as by the amount of weight removed. Research has shown that a typical grass plant needs at least 50% of its leaf surface to remain vigorous and productive. Grass plants need the food manufactured by the remaining leaves in order to regrow and survive. Thus, utilization estimates are made on individual plants, but what is of real interest is whether all plants throughout the pasture are receiving a level of use that will promote vigor and sustained production.

Here are some specific situations where a manager may want to monitor pasture utilization:

- A pasture is scheduled to be used in early summer for one month, but after just three weeks of grazing, utilization estimates indicate that the desired use (say 50%) has already been achieved. The manager may elect to rotate livestock to a fresh pasture to prevent decreased animal performance or loss of plant vigor.

- The same pasture, in a different year, has been grazed for its budgeted one month; utilization estimates show 25 percent use. Grass in the next pasture scheduled to be grazed has not grown as expected. The manager elects to hold stock in the first pasture for an additional two weeks, knowing utilization levels will not be excessive. The next pastures will have the benefit of increased vigor and production as a result of the delayed turnout.

- Non-uniform patterns of use in a pasture are a clear sign that forage harvest efficiency is not optimum. If the disparities in degree of use are sufficiently large, the manager may cross-fence the pasture, develop water, or change the seasons of use to give more uniform utilization and greater animal production.

- Utilization estimates over several representative years clearly demonstrate which individual pastures or ranch units are overstocked or understocked. The manager uses this information to decide whether the ranch can sustain the existing stock or whether stock numbers should be changed -- either up or down.

- Utilization records for a pasture over several grazing seasons provide evidence whether use levels are contributing to improvement or deterioration in range health and productivity. For example, when the manager feels that range condition appears to be deteriorating, a utilization record might suggest several possibilities:
  -- Livestock grazing is or is not the likely culprit.
  -- Weather fluctuations might be partly responsible.
  -- Adjustments in season of use are warranted.
  -- Stock reductions may be required.

Applying Utilization to Management

The complexity of grass utilization patterns in many situations, except tame pasture monocultures, dictates a need to simplify procedures for utilization estimates. This is accomplished by selecting key grasses (indicator grasses) in key areas for utilization estimates rather than by estimating utilization for all species. Unless the manager resorts to a single or a few key species for utilization estimates, he will be confronted by a large variety of species, each utilized to a different degree depending on its availability, location, season of use, and animal preferences.

Selecting Key Grasses for Measurement

Key grasses are vital to maintenance of livestock carrying capacity and animal performance. These grasses (or indicator grasses) selected for utilization estimates are important for different reasons. A species selected as key should fit one or both of these criteria:

- It is one of the most abundant species in the pasture during the season of livestock use, and it makes up a large portion, even the major portion, of the animal's diet.

- It has indirect value in the pasture. Correctly called an indicator, this grass is not abundant enough to produce much forage. However, it is judged to be important from the standpoint of plant species diversity, wildlife value, soil stability, nutrient cycling, or similar biological criteria.

A word of caution: Highly preferred species ("ice cream" plants) in many range situations may occur in only small quantities. On these species, higher levels of use often are tolerated in order to obtain fuller use of more abundant species. However, "ice cream" plants generally can be maintained or even increased in a pasture if grazing deferments permit them to recover during their critical growth periods.

In general, correct grazing for one, two, or three key forage plants means correct grazing for the entire pasture.

Selecting Key Areas for Measurement

Analogous to the key plant concept for determining utilization is the key area theory. Just as a single species or group of species is a key to correct use, so a representative area may be selected to estimate utilization. The principle is that no pasture of appreciable size or complexity is used uniformly. Heavy use is inevitable near watering locations, salt grounds, level valley floors, and more accessible ridge tops. Likewise, lighter use, or even nonuse, may prevail at great distances from water and on very steep hillsides.

Certain areas may be designated as sacrifice areas and will be overused just as the uncommon and highly preferred species may be overused. Other areas will most likely be underused, since their full use would cause serious overuse and range damage to more accessible areas. The intermediate areas, then, become the key areas from which to judge utilization of the pasture. However, if you want to make a use map for the pasture, utilization will be estimated in all major representative areas of the pasture.

Selecting Dates for Measurement

After the Grazing Period

Estimate utilization as soon after the grazing period ends as is possible.

For season-long grazing in South Dakota, about mid-October is the best time to assign final yearly use ratings.

For pastures grazed once, but briefly -- typically one to three months -- estimate utilization as close to the livestock removal dates as possible. This is especially important, because grass continues to grow and the longer you delay estimating utilization, the more distorted and misleading your estimates of use will be.

For pastures grazed more than once in a season, make utilization estimates at the end of each use period, on the appropriate key species for that period.

During the Grazing Season

Mid-season estimates are useful for predicting when the desired use level will be reached. Adjustments in stock numbers often can be made by rating utilization in mid-season. Early-season stocking manipulations (mid-season or earlier) can help to avoid serious overuse in dry years or to take advantage of surplus forage in good years.

Determining Utilization

Use Rating Classes

Six use rating classes define categories into which visual estimates of utilization can readily be placed. Table 1 gives a brief description of utilization in each class. These ratings are used by the Soil Conservation Service and others and are the standard for defining range or cultivated pasture utilization levels.

Individual Plant Photo Guides

Photographs in this guide (pages 10 through 17) show six levels of use for eight species common to South Dakota ranges and cultivated pastures. Plants have been clipped to show utilization of 0% (unused), 10%, 30%, 50%, 70%, and 90%. These use levels are designed to aid in placing utilization estimates in a specific use rating class.

Determining the use rating is quite easy and fast for individual plants or areas in a pasture. The grazed plant(s) is compared to the photographs of that species which show various levels of use. In actual practice, grazed plants are first compared to ungrazed "neighbors" to get a feel for their original height. Then the percent height removed is estimated and the photo guides are used to categorize the percent of use (by weight). The best fit between the grazed plant and the photographs allows direct placement into one of the use ratings described in Table 1. Utilization estimates for individual plants are averaged or expanded to represent use of the area. (See Paced Transect Method.)

A special caution is needed. The photographed plants are relatively tall for some parts of the state and for some growing conditions. However, the relationship between a plant's height and its weight is consistent. Therefore, when you estimate utilization on a plant whose unused height is different from that in the photo guides, take care to judge use in relation to proportion of the height grazed, not the actual "inches" of height grazed. Ignore the inch increment marks and think of the grid in terms of proportion of the ungrazed height versus the grazed height.

It often will be useful to use "bracketing" to discern the proper use rating class. This is done by asking a series of questions that tightens the bracket. For example:

Question 1. Is the grazed plant (or plants in the area) grazed more or less than 50%?

Answer 1. By comparison to the photographs it is clearly grazed less than 50%.

Table 1. Use rating class descriptions for varying levels of use.

Use Rating Class	Use of Current Year's Growth[1]	Whole-Pasture Use Description
UNUSED	0%	No livestock use
SLIGHT	1 to 20%	Appears practically undisturbed when viewed obliquely. Only choice plants and favored areas near water, trails, or shade are grazed.
MODERATE	21 to 40%	Most all of accessible pasture shows grazing. Little or no use of poor forage. Little evidence of trailing to grazing.
FULL	41 to 60%	All fully accessible areas are grazed. The major sites have key forage species properly utilized (about 1/2 taken and 1/2 left).[2] Points of concentration with overuse limited to between 5% and 10% of accessible area.
CLOSE	61 to 80%	All accessible pasture plainly shows use and major sections are closely cropped. Livestock forced to use much poor, dry, and stemmy forage considering seasonal preference.
SEVERE	81 to 100%	Key forage species almost completely used. Low-value forage carrying grazing load. Trampling damage widespread in accessible areas.

[1]These use categories apply to individual plants as well as to average area or whole-pasture use.
[2]The reference to "proper utilization (about 1/2 taken and 1/2 left)" is the Soil Conservation Service standard for weight removal. Proper utilization, depending on circumstances, can range from a low of "unused" to a high of "close."

Question 2. Is the plant grazed more or less than 30% (but less than 50% as established with Answer 1)?

Answer 2. By comparison to the photographs, it is grazed more than 30%, but it is closer to 30% than to 50%.

The conclusion is, therefore, that the plant or area falls in the 21-40% Class, which is **Moderate use.**

This process for determing utilization is known as the Grazed-Class Photo Guide procedure.

Making a Pasture Use Map

Once degree of use estimates can be made for key species, a use map or use pattern map is often the next logical step. Use pattern maps reveal grazing patterns within a pasture and can be used to suggest where improvements like water developments or fence changes should be made. Changes would be suggested where large areas of under- or over-utilized forages occur.

A use map is simply a general map of the pasture completed near the end of the grazing season or grazing cycle. It need not be technical or detailed and should not require much time to complete. Yet the use map, created diligently each year on each pasture in question, is probably the most valuable range monitoring record a manager can maintain.

An existing range inventory map drawn on an aerial photograph makes an excellent base map. The use map can be made on a photocopy of the inventory map. In the absence of a range inventory, a use map can be made from any property map that shows fences, water sources, and major terrain features that influence livestock movement. Record the use within each major range site/condition mapping unit or significant

terrain feature in the pasture. These zones of use are compiled on a map, as shown in Figure 4.

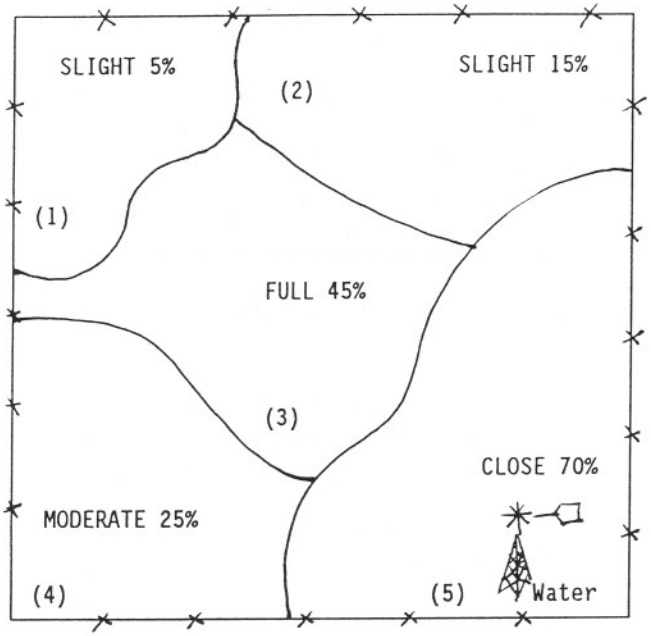
The sampling procedure requires that every **zone of use** (mapping unit) is visited to make estimates of use for the **key species** in each zone. The intensity of sampling depends on the complexity of the vegetation, topography, and the degree of accuracy desired. To obtain a representative use estimate, sample the zone perpendicular to drainages, soil variation, slopes, and trails.

A good "feeling" for degree of use in a zone can be made by mentally integrating the visual impression of utilization for the zone into a single value and comparing to the grass use photo guides for placement into the appropriate use rating class. For many purposes, this approach is adequate for estimating current species use. Referring to the photographs of pasture utilization (pages 18 through 28) also may be helpful.

Paced Transect Method

When more accurate utilization estimates are required, walk in a straight line, or serpentine through the zone to be mapped, taking samples at regular intervals, either at each pace or every other pace. Utilization of the key species nearest and forward of the same toe is recorded in one of six use classes using the Dot-Dash Tally method (see Figure 5). Generally, you should take 50 plant samples for 90% accuracy, 100 samples for 95% accuracy. To calculate **current use** of a key species in a zone, sampled plants are tallied in each use class (Figure 5).

Figure 4. Final use map of pasture showing zones of use on a key species.



If 50 plants are sampled, double the dot-dash tallies to determine grazed plants percentage in each use class. If 100 plants are sampled, Dot-Dash Tallies equal grazed plant percentages in each use class. The current use percentage is determined by multiplying each mid-point percentage by the grazed plant percentage and dividing by 100. The sum of the current use percentages is the **total current species use** in percent.

Once the monitored pasture has been adequately sampled, the second step is to record either the use class percentage or the **total current species use** percentage or its corresponding **use rating** from Table 1. Place these entries on the **pasture use map**, Figure 4.

Estimating Proper Stocking Rate and Carrying Capacity

Proper Range and Pasture Use

It is not the intent of this publication to address the intricacies of proper range or pasture use, but a brief discussion is appropriate inasmuch as degree of use is the mechanism for determining whether a pasture is properly used. Experiences and research in the Northern Great Plains have repeatedly demonstrated that there is a clear relationship between degree of use and the maintenance of range and cultivated pasture production.

Full use (41-60%) of rangelands during the growing season, as an average over the years, is known to sustain vegetation productivity and reliant livestock carrying capacity. Full use is not necessarily proper use. Full use generally will maintain a pasture, but it is not as beneficial for pasture improvement as are lesser degrees of use.

Moderate use (21-40%) frequently has produced more profit, over a longer period of time, with fewer animals, than have higher stocking rates.

In drought years, moderate rates of stocking can produce **close use** (61-80%). Where use is entirely during winter, proper use in some situations may be close use.

Appropriate grazing systems will result in more uniform use and will give beneficial periods of non-use for important species groups. Grazing systems should improve efficiency of forage harvest, but grazing systems alone are not a substitute for proper grazing use.

Figure 5. An example of a dot-dash tally form that can be used to calculate current species use for each use mapping unit. (Schmutz, 1978.)

PROJECT _____ DATE Nov. 1, 1994

PASTURE High Tower SURVEYOR JRJ

Location: Key Species:				Location: Key Species:			
Use Class (%) / Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)	Use Class (%) / Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0	⊠⊏	17	0.00	0			
1-20: 10	⊠⊠⊏	27	2.70	1-20: 10			
21-40: 30	⊠⊠⊠	43	12.90	21-40: 30			
41-60: 50	⊠··	13	6.50	41-60: 50			
61-80: 70		0	—	61-80: 70			
81-100: 90		0	—	81-100: 90			
Total Current Species Use (%)			22.10	Total Current Species Use (%)			

Location: Key Species:				Location: Key Species:			
Use Class (%) / Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)	Use Class (%) / Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				0			
1-20: 10				1-20: 10			
21-40: 30				21-40: 30			
41-60: 50				41-60: 50			
61-80: 70				61-80: 70			
81-100: 90				81-100: 90			
Total Current Species Use (%)				Total Current Species Use (%)			

Ranges that are overstocked will be overused before the end of the grazing season unless stocking rate is reduced at mid-season. Pastures that are overused year after year show signs of overgrazing with disappearance or decreased vigor of more productive forage species, regardless of grazing system in use.

Estimating Proper Current Stocking Rate and Carrying Capacity

The **grazed-use class** method of estimating utilization has been used by Schmutz (1978) to make mid-season stocking adjustments so that pastures can be more nearly grazed at their full or proper forage use capacities. Proper forage use is variable. Final estimates of forage utilization also may be made to determine proper annual carrying capacities.

To make mid-season (interim) estimates of proper current stocking rates, make utilization surveys after full growth of forage and before the end of season. You can use the utilization estimates (proper forage use and current forage use), along with the animal unit months used (grazed), to estimate the proper number of animal unit months remaining in the current grazing year:

$$\text{Animal Unit Months Remaining} = \frac{\text{Proper Forage Use (\%)} - \text{Current Forage Use (\%)}}{\text{Current Forage Use (\%)}} \times \text{Animal Unit Months Used}$$

To calculate an estimate of the stocking rate necessary to properly use a pasture for the remainder of the grazing season, the Animal Unit Months remaining are divided by the calendar months of grazing remaining. An estimate of the current year's projected total carrying capacity can be calculated by adding Animal Unit Months Used to estimated Animal Unit Months Remaining.

Estimating Proper Annual Carrying Capacity

At the end of the grazing season, a utilization survey can be made on a given area to determine the proper annual carrying capacity in relation to the actual animal units grazed:

$$\text{Proper Annual Carrying Capacity in Animal Unit Months} = \frac{\text{Proper Forage Use (\%)}}{\text{Actual Forage Use (\%)}} \times \text{Actual Animal Unit Months Grazed}$$

Actual forage use is calculated at season's end. Accumulation of proper use data for several years will give an estimate of the average annual proper carrying capacity for the pasture.

Effect of Plant Growth on Use Estimates

These grazed-use class approaches for estimating proper stocking rate and carrying capacity are designed for use on pastures after normal seasonal growth is completed. In dry years when plants don't complete their growth, the guide won't distinguish between use and non-growth. In these circumstances, the method can be used to estimate proper use and proper annual carrying capacity at the end of the grazing season, but interim estimates of annual carrying capacity will be low. Where grazing season growth is an important factor, proper use and proper annual carrying capacity can be estimated at the end of the grazing season, but the interim estimates of annual carrying capacity will be high.

Photo Guides for Key South Dakota Grasses

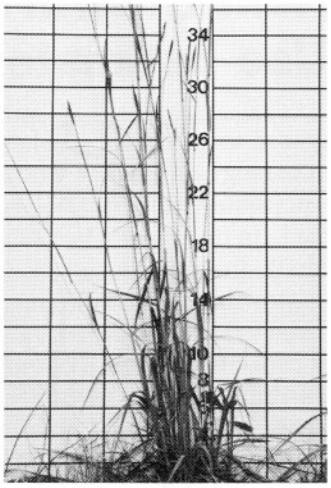
The eight grasses shown on pages 10 through 17 are among the most common forages on range and seeded pastures. Grass height varies considerably from year to year and place to place. Therefore, in order to use these photographs for degree of use estimates in the field, the grid increment marks must be interpreted in terms of proportion of unused (0%) versus grazed height. Do not compare "inches of stubble remaining" between field samples and the photographs, unless the ungrazed height of both is the same.

Visual Estimates of Pasture Utilization

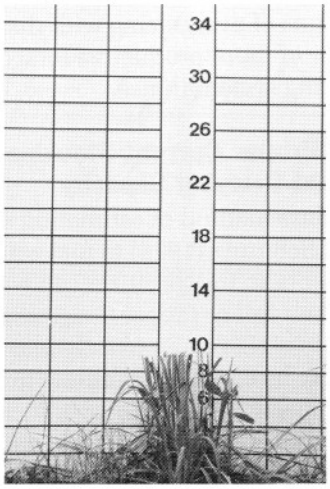
The photographs on pages 18 through 28 provide for comparative evaluation of degree of use for different range sites and cultivated pastures in several parts of South Dakota.

Photo Guides for Key South Dakota Grasses

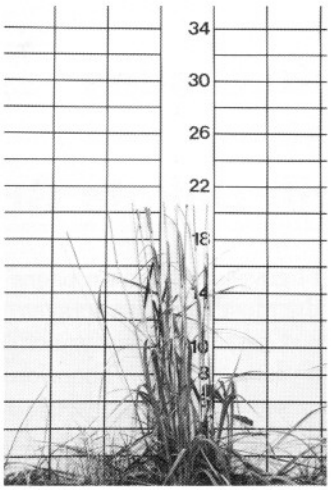
Big Bluestem Use



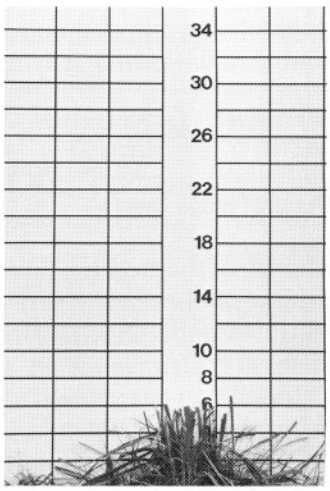
Unused 0%



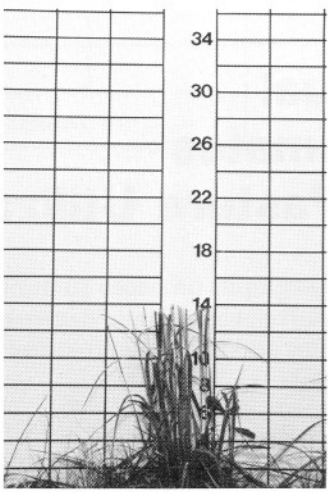
Full 50%



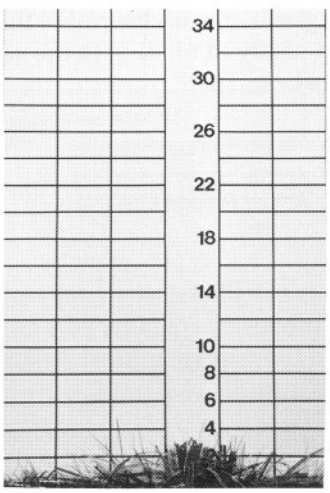
Slight 10%



Close 70%



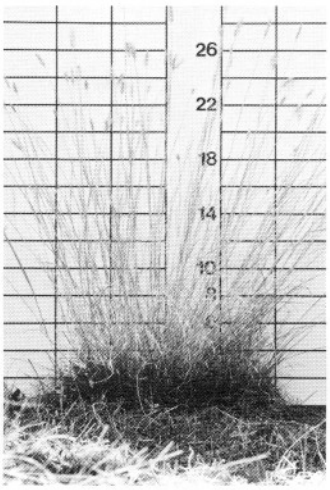
Moderate 30%



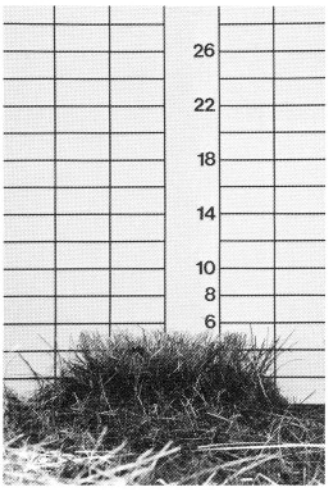
Severe 90%

10

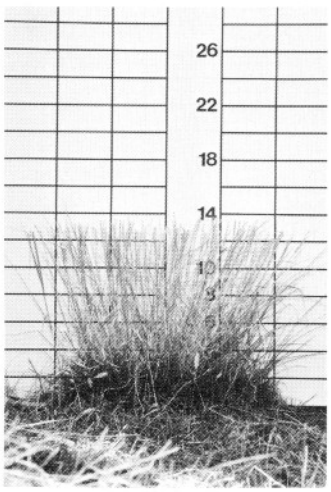
Crested Wheatgrass Use



Unused 0%



Full 50%



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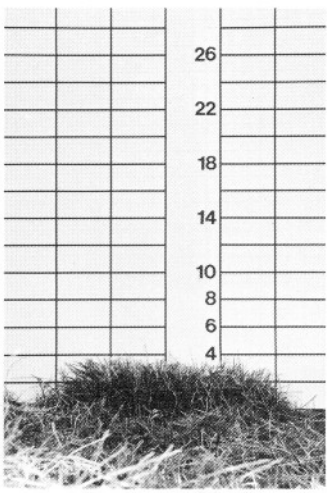
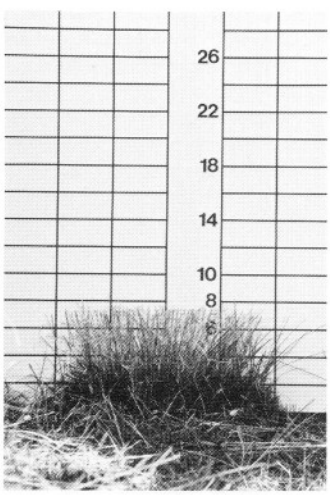
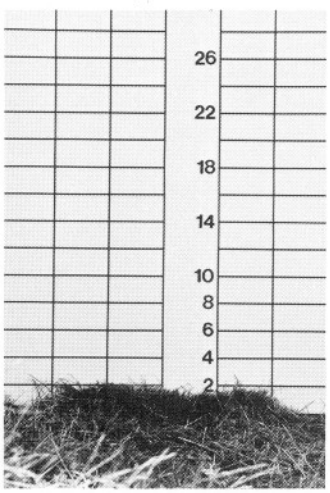


Close 70%



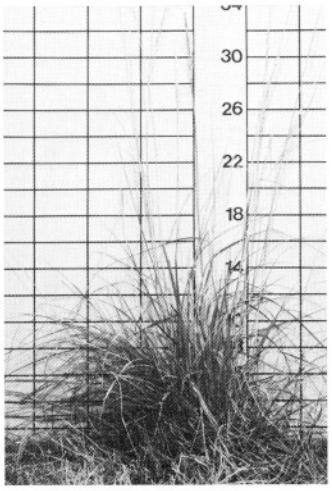
Moderate 30%



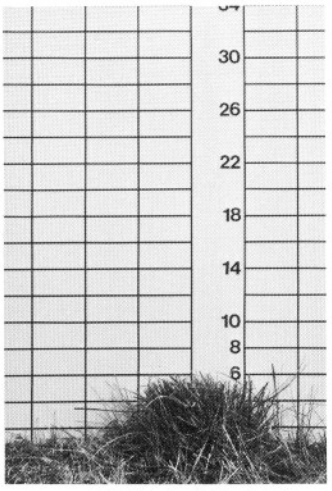
Severe 90%

11

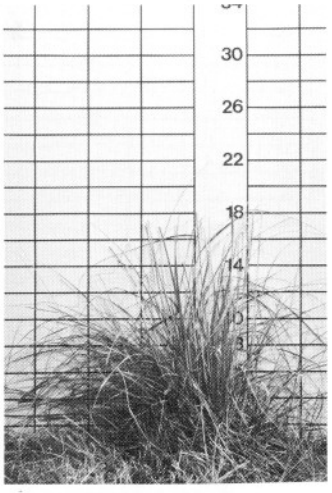
Green Needlegrass Use



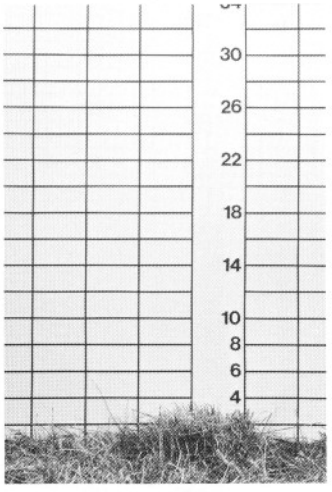
Unused 0%



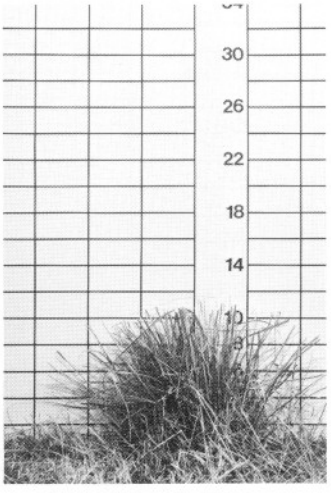
Full 50%



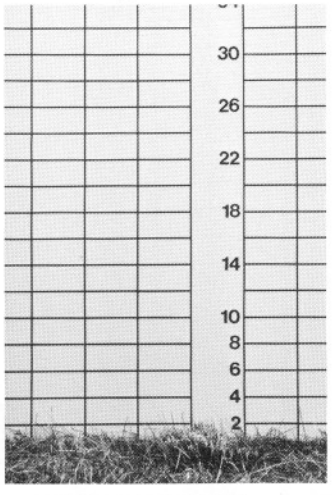
Slight 10%



Close 70%



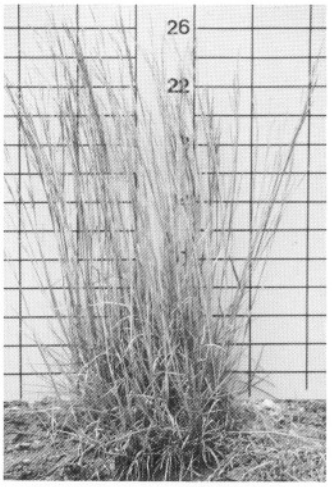
Moderate 30%



Severe 90%

12

Little Bluestem Use



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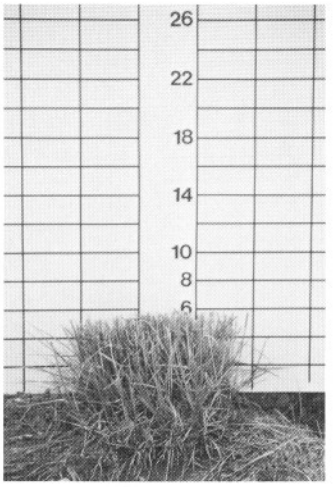

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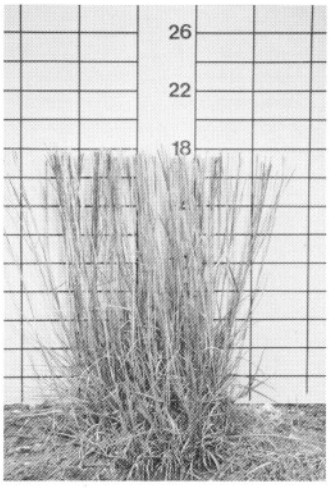

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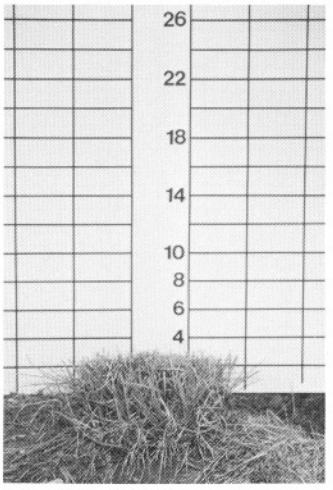

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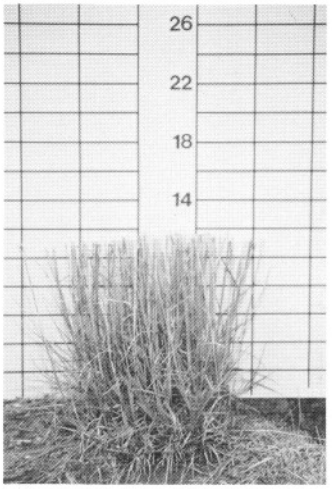
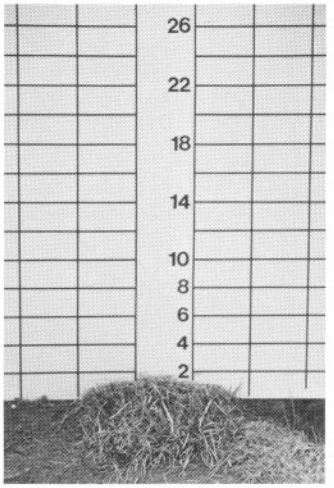


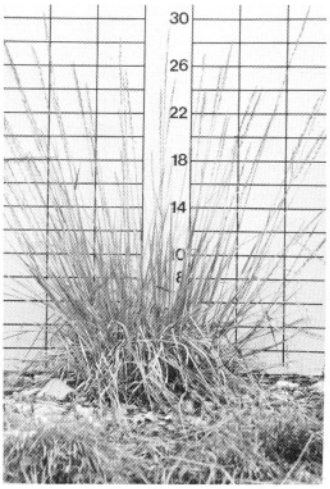
Moderate 30%



Severe 90%

13

Sideoats Grama Use



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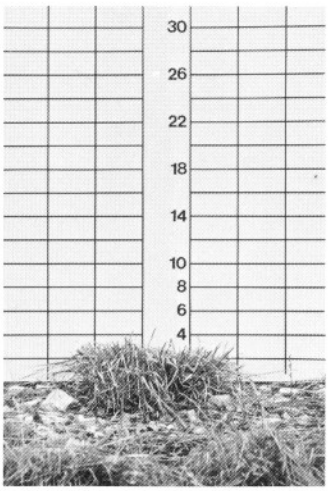

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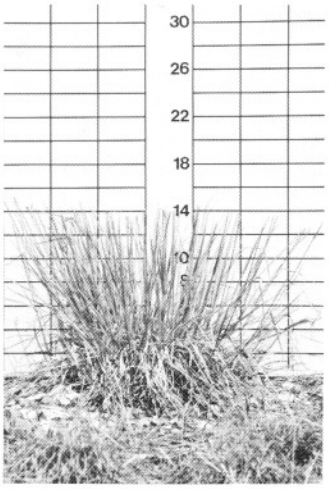

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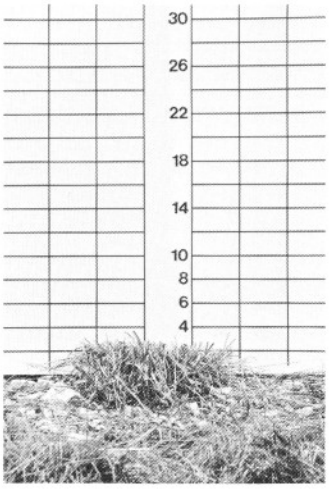

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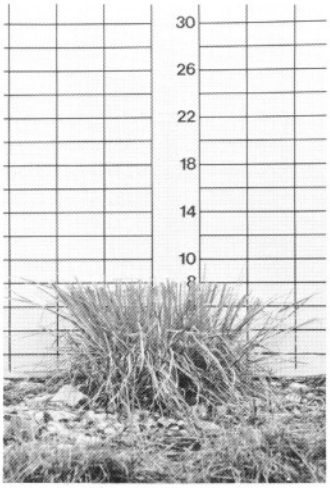
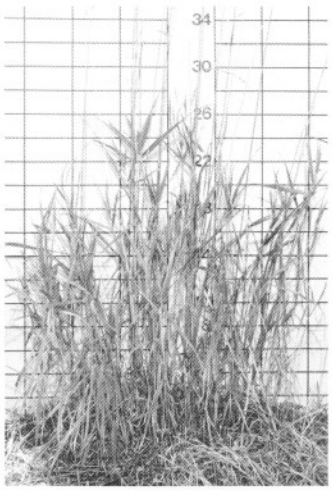


Moderate 30%

14

Smooth Bromegrass Use



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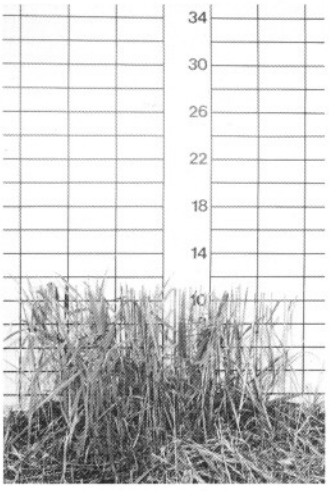
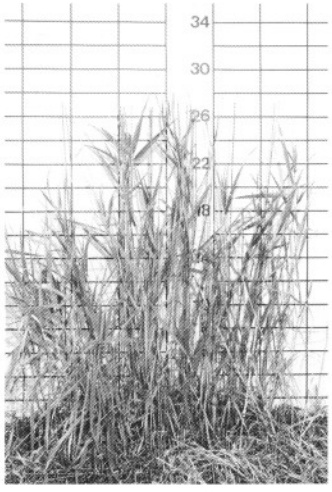


Full 50%



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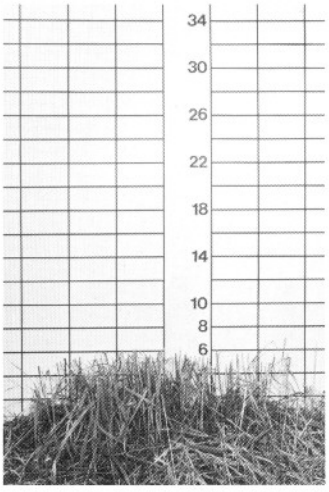

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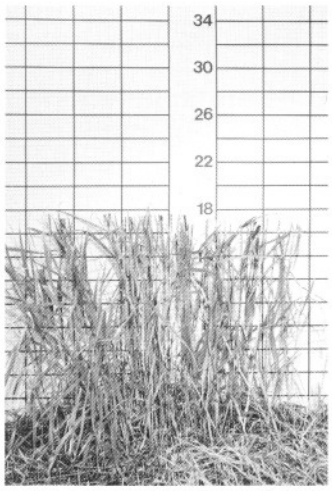
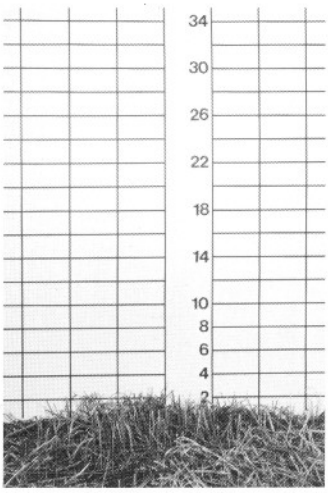


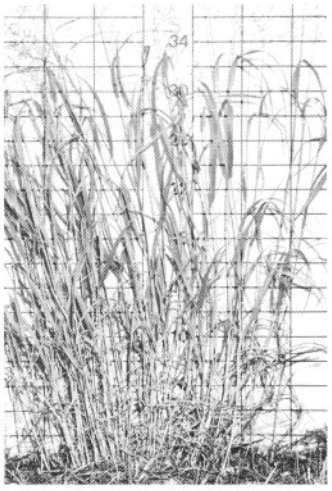
Moderate 30%



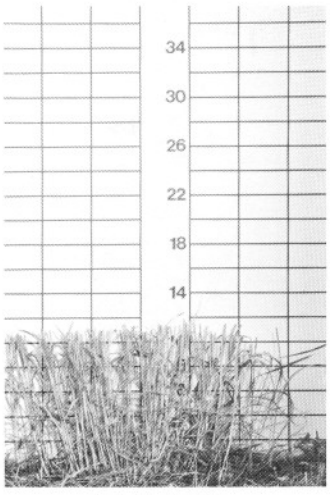
Severe 90%

15

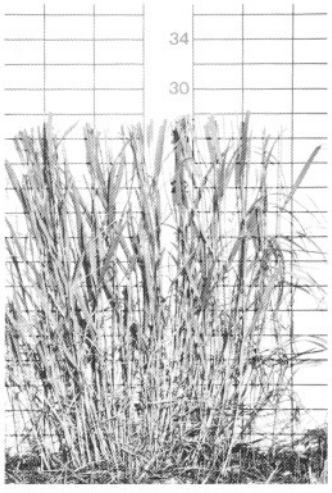
Switchgrass Use



Unused 0%



Full 50%



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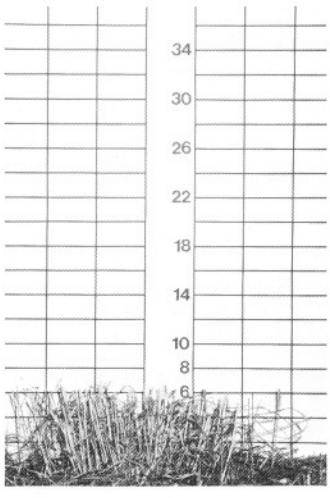

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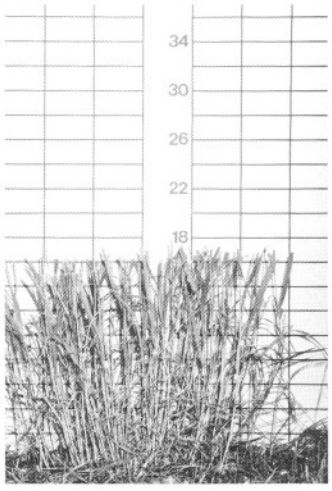

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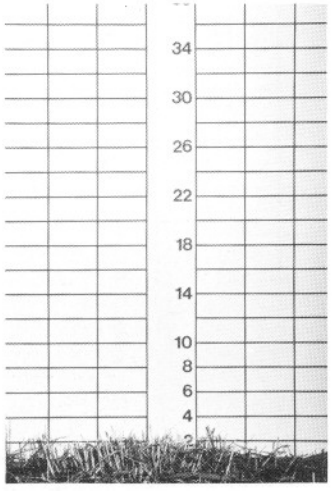
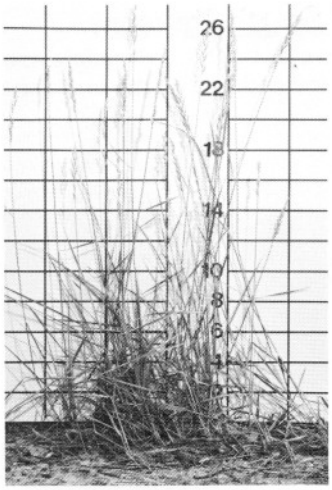


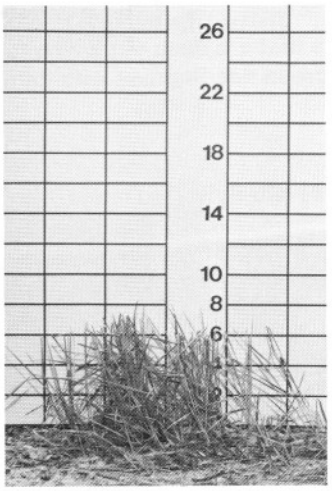
Severe 90%

16

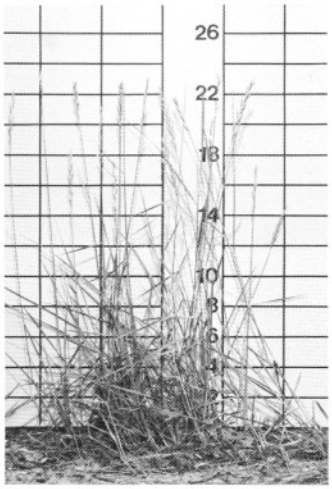
Western Wheatgrass Use



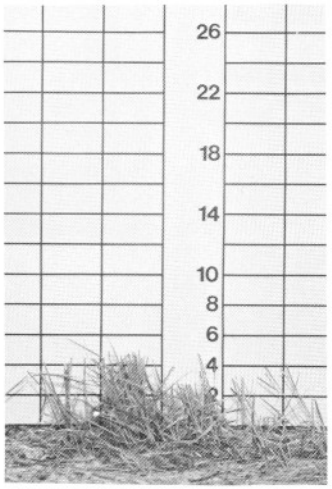
Unused 0%



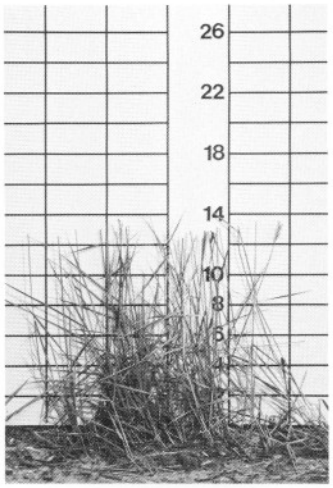
Full 50%



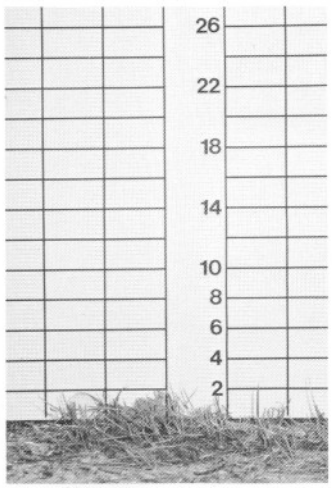
Slight 10%



Close 70%



Moderate 30%



Severe 90%

17

Visual Estimates of Pasture Utilization

Clayey range site, central South Dakota

This site has soils that are deep silt loams to clay with a silty clay to clay subsoil. Principle species are western wheatgrass and green needlegrass with blue grama, buffalograss, and sedges. Forbs and shrubs usually are not abundant.

Slight Use (10%)

Close examination is required to find evidence of animal activity or grazing. Use on individual plants is less than 20%. Almost all use is on grass blades. Fewer than 50% of all plants have been grazed.

Buffalo County.

High - good condition.

2,800 lbs. remaining.

Moderate Use (35%)

Trampling disturbance is easily seen. Most individuals of the preferred species have been grazed slightly. Almost no grass is grazed greater than 50% use. Flowering stems or blades protected by stems are seldom grazed. Pasture use generally is uneven.

Buffalo County.

Excellent condition.

2,500 lbs. remaining.

18

Clayey range site, central South Dakota (continued)

Full Use (45%)

Trampling and grazing apparent. Most individuals of palatable species are grazed, many more than 50%. Green needlegrass grazed; flowering stems knocked down, although most not grazed. Western wheatgrass seed heads still evident. Pasture use generally is uniform.

Buffalo County.

High - good condition.

1,500 lbs. remaining.

Close Use (65%)

A stubble-like appearance exists, except much plant material is lodged from trampling. Use is very uniform, most individuals grazed at 35% or greater. Ground cover still good in wet year. Resource could not sustain this level of use.

Buffalo County.

High - good condition.

900 lbs. remaining.

19

Clayey range site, central South Dakota (continued)

Severe Use (90+%)

Stock would find difficulty getting a full mouth of forage. Much is broken, lying flat, unavailable. Low value forages grazed. Fecal material, rocks, or cactus often a major visual feature. Bare soil easily visible. Repeated use at this level will cause production declines and elevated erosion potential.

Buffalo County.

High-good condition.

200 lbs. remaining.

Silty range site, central South Dakota

This site, often on rolling uplands, has deep soils that provide good soil-water-plant relationships. Tall grasses like big bluestem often are co-dominant will several other grass species and forbs. Leadplant and rose often occur.

Slight Use (10%)

Close inspection is required to see evidence of grass use or forage trampling. Minor trailing may be evident through tall grass stands.

Beadle County.

Excellent condition.

Silty range site, central South Dakota (continued)

Moderate Use (25%)

Selective grazing pressure on highly palatable species like bib bluestem and succulent forbs. Aspect and stature of community is still that of tall grasses. Some areas may have full grazing use, others may be lightly used.

Beadle County.

High condition.

Severe Use (90%)

Essentially all available plant material has been grazed. Ground cover here is still high, but repeated use at this level will eventually result in greatly diminished forage production and increase the potential for erosion.

Beadle County.

High condition.

21

Clayey range site, western South Dakota

Silt loam to clay loam surface soil has a clayey subsoil. Principle species are western wheatgrass with green needlegrass and shorter species and sedges.

Moderate Use (35%)

Patterned grazing use is evident; most seed stalks remain standing. Few individuals grazed more than 50%. All preferred species show some grazing use.

Pennington County.

High - good condition.

Close Use (70%)

Key forage species are gazed to the maximum; many others are grazed to 50% use. No patches are ungrazed. Individual grasses that matured early and became coarse often are only moderately grazed. Much soil is exposed; erosion potential is elevated.

Pennington County.

Good condition.

Overflow range site, western South Dakota

These sites, with sandy to clayey soils, are deeply developed and highly productive due to overflow water. Species composition varies with soils and location in the state, but big bluestem and western wheatgrass, along with other tall grasses, often are dominant. Shrubs, trees, and forbs are common from place to place.

Unused (0%)

In an unused state, many of the grasses fully mature and develop abundant seed heads because of supplemental water.

Harding County.

High - good condition.

Moderate Use (35%)

Preferential grazing on big bluestem is seen with full or close use, resulting in greatly reduced number of seed producing stems. Use is spotty if several grass species are abundant. Trampling is evident, but most vegetation remains standing.

Harding County.

Good condition.

23

Overflow range site, western South Dakota (continued)

Close Use (75%)

Much grass is grazed to height of lawn mower; less palatable grasses remain essentially ungrazed. Livestock sign is common. Erosion hazard not necessarily elevated if grazing-resistant species like Kentucky bluegrass occupy site.

Harding County.

Lo- good condition.

Crested wheatgrass pasture

Slight Use (10%)

Evidence of use is difficult to see. Almost no plants are fully used.

24

Crested wheatgrass pasture (continued)

Moderate Use (30%)

Evidence of use is easy to see. Some plants grazed more than 50%. Majority of plants not grazed or grazed around edges only. Some trampling is apparent.

Severe Use (70%)

Most plants grazed to short stubble height. Many ungrazed "wolf" plants may give appearance that pasture is not severely used. Wolf plants go ungrazed from year to year.

25

Smooth bromegrass pasture

Moderate Use (35%)

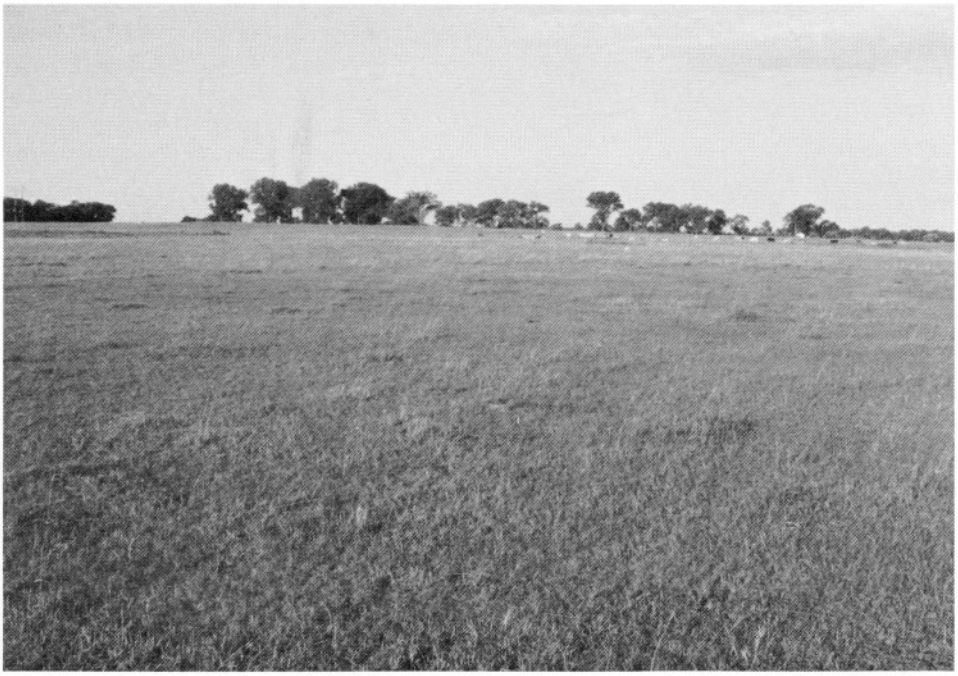
Use appears very selective, grazing mostly on upper leaf blades. Some seed stalks may have been grazed. Very few, if any, areas have been closely grazed, thus grazing is not patchy.

Full Use (55%)

Nearly all plants grazed. Most grazed to near 25% of their ungrazed height. Areas grazed less heavily have "spotty" grazing appearance.

26

Smooth bromegrass pasture (continued)



Close Use (70%)

Pasture looks like it has been mowed for hay, except for occasional seed stalks which are only partially grazed.

Switchgrass pasture

Moderate Use (25%)

Most disturbance appears to be from minor trampling. Grass use is limited to upper leaf blades of most individual plants.

27

Switchgrass pasture (continued)

Full Use (50%)

Use has clearly decreased overall plant height; most individual grasses grazed, including some seed head use and breakage. A few individual plants have been grazed severely.

Close Use (70%)

Leaves thoroughly utilized; mostly tall stem stubble remaining.

28

Glossary*

Actual forage use (%). Syn. *use.*

Animal-unit-month. The amount of dry forage required by one animal unit for one month based on a forage allowance of 26 pounds per day. Not synonymous with *animal-month.* Abbr. AUM. The term AUM is commonly used in three ways: (a) Stocking rate, as in "X acres per AUM"; (b) forage allocations, as in "X AUMs in Allotment A"; (c) utilization, as in "X AUMs taken from Unit B.

Carrying capacity. The maximum *stocking rate* possible which is consistent with maintaining or improving vegetation or related resources. It may vary from year to year on the same area due to fluctuating forage production.

Current forage use (%). Used to suggest additional grazing is planned. Syn. *use.*

Degree of use (%). The proportion of current year's forage production that is consumed and/or destroyed by grazing animals. May refer either to a single species or to the vegetation as a whole. Syn. *use.*

Key species. (1) Forage species of sufficient abundance and palatability to justify its use as an indicator of the *degree of use* of associated species. (2) Those species which must, because of their importance, be considered in the management program.

Overgraze. Continued heavy grazing which exceeds the recovery capacity of the community and creates a deteriorated range. Compare to *overuse.*

Overstock. Placing a number of animals on a given area that will result in *overuse* if continued to the end of the planned grazing period.

Overuse. Utilizing an excessive amount of the current year's growth which, if continued, will result in *range deterioration.* Compare to *overgrazing.*

Pasture. (1) A grazing area enclosed and separated from other areas by fencing or other barriers; the management unit for grazing land. (2) Forage plants used as food for grazing animals. (3) Any area devoted to the production of forage, native or introduced, and harvested by grazing. (4) A group of subunits grazed within a rotational grazing system.

Proper use (%). A degree of utilization of current year's growth which, if continued, will achieve management objectives and maintain or improve the long-term productivity of the site. Proper use varies with time and systems of grazing. Syn. *proper utilization, proper grazing use*; cf. *allowable use.*

Proper forage use (%). Syn. *proper use.*

Range or Rangeland. (n) Uncultivated lands that provide necessities of life for grazing and browsing animals. Rangelands may include all but barren deserts, naturally occurring grasslands or shrublands, high alpine meadows, or forested and wooded lands having grazing or browsing value. Range is not a use. (adj.) Modifies resources, products, activities, practices, and phenomena pertaining to rangeland.

Season of use. Grazing restricted to a specific season.

Stocking rate. The number of specific kinds and classes of animals grazing or utilizing a unit of land for a specified time period. May be expressed as animal unit months or animal unit days per acre, hectare, or section, or the reciprocal (area of land/animal unit month or day). When dual use is practiced (eg., cattle and sheep), stocking rate is often expressed as animal unit months/unit of land or the reciprocal. Syn. *stocking level.*

Tame pasture. A pasture which has been *cultivated* and *seeded* to forage species.

Turnout. Act of turning livestock out on the range at the beginning of the grazing season.

Underuse. A degree of use less than proper use.

Understock. To place a number of animals on a given area that will result in *underuse* at the end of the planned grazing period.

Use rating (class). Assignment of use (%) into one of six categories: unused (0%), slight (1-20%), moderate (21-40%), full (41-60%), close (61-80%), or severe (81-100%).

Use (%). The proportion of current year's forage production that is consumed or destroyed by grazing animals, commonly expressed as a percentage. May refer either to a single species or to the vegetation as a whole. Syn., *degree of use.*

Utilization (%). Syn. *use.*

*Adapted from Jacoby (1989)

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Taylor, John E. and John Lacey. 1987. Monitoring Montana rangelands. Montana State University Cooperative Extension Bulletin 369.

Jacoby, Peter W. 1989. A glossary of terms used in range management. Society for Range Management, Denver, Colo.

PROJECT ______________________ DATE ______________________

PASTURE ______________________ SURVEYOR ______________________

Location:
Key Species:

Use Class (%)	Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				
1-20:	10			
21-40:	30			
41-60:	50			
61-80:	70			
81-100:	90			
Total Current Species Use (%)				

Location:
Key Species:

Use Class (%)	Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				
1-20:	10			
21-40:	30			
41-60:	50			
61-80:	70			
81-100:	90			
Total Current Species Use (%)				

Location:
Key Species:

Use Class (%)	Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				
1-20:	10			
21-40:	30			
41-60:	50			
61-80:	70			
81-100:	90			
Total Current Species Use (%)				

Location:
Key Species:

Use Class (%)	Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				
1-20:	10			
21-40:	30			
41-60:	50			
61-80:	70			
81-100:	90			
Total Current Species Use (%)				

Location:
Key Species:

Use Class (%)	Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				
1-20:	10			
21-40:	30			
41-60:	50			
61-80:	70			
81-100:	90			
Total Current Species Use (%)				

Location:
Key Species:

Use Class (%)	Mid-Point (%)	Dot-dash Tally	Grazed Plants (%)	Current Use (%)
0				
1-20:	10			
21-40:	30			
41-60:	50			
61-80:	70			
81-100:	90			
Total Current Species Use (%)				

SDSU Coop. Ext. Ser. EC 900 after Schmutz, 1978.

Phenology User Guide

USFWS Native Prairie Adaptive Management

10 October 2012

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INTRODUCTION

The Native Prairie Adaptive Management Project (NPAM) decision framework for tallgrass units is built around the concept that cool-season windows (fall and spring) exist during which grassland management can impact cool-season invasive grasses without negatively impacting native warm season grasses (e.g., Willson and Stubbendieck 2000). Defoliation within the window occurs through either a prescribed fire or grazing event. Timing and duration of the defoliation event relative to the cool-season window is critically important. Neither the fall nor spring cool-season window is static. Start and end periods for both fall and spring windows likely differ among years and locations, making phenology data an important component of monitoring (and management).

Because of the need to collect consistent and accurate data on phenology, this guide was created as a stand-alone reference for NPAM cooperators who manage tallgrass units. Identifying phenological stages provides critical data to inform the tallgrass model. The subsequent protocols should provide necessary details to collect these data, without imposing an inordinate workload on the cooperators. These phenology data protocols do not impose an excessive work load; they are, however, exceedingly important and require a commitment from the cooperators to consistently follow the guidelines outlined here. This is especially important due to the natural variation in the data being collected.

For some aspects of this project, there is little to no information in the literature to guide phenology-based management. It is unclear at which phenological stage Kentucky bluegrass may be most vulnerable to fire (Sather 1996). At the time of this writing, Dr. Shawn DeKeyser and colleagues at North Dakota State University have initiated research on Kentucky bluegrass management. Similarly, there is less specific information available regarding management applications in fall than is available for spring. It is our hope that the phenology data collected through NPAM and other ongoing research will allow us to revise and refine some of the phenological stages described in this document.

Phenology data are collected for NPAM at two spatial scales: 1) the management-unit scale, and 2) the station-level scale. These are two related but different data collection efforts.

1. MANAGEMENT UNIT PHENOLOGY

Management unit-level phenology data are required to determine whether a burn or graze management action occurs in or out of the cool-season window.

1.1 MANAGEMENT UNIT PHENOLOGY | WHO COLLECTS DATA

Management unit phenology will be monitored by NPAM cooperators with tallgrass prairie units. The project coordinator and advisory team will provide training and guidance as needed to ensure consistent, reliable data collection (typically this training will occur as part of the Field Activity Workshops). Ideally, the same staff member (usually the biologist or manager) will collect phenological data within and among years.

1.2 MANAGEMENT UNIT PHENOLOGY | WHERE TO COLLECT DATA

Management unit phenology must be monitored at each tallgrass management unit that is receiving a burn or graze management action. A single "measurement" may entail data collection at more than one sampling location within and possibly adjacent to a unit, depending on whether a burn or graze is implemented. The single measurement for a burned unit and the measurement at the beginning of a grazing event are made within the management unit. However, because a grazing event alters phenology within a grazed unit, the phenology measurement at the end of the graze is made on a nearby *reference unit* that was not grazed or burned during the management year. The reference unit should be chosen such that at the beginning of the grazing event, the reference unit has the same phenological stage as the management unit that is about to be grazed (e.g., beginning leaf-stage of smooth brome should be the same on the unit receiving management and the reference unit).

1.3 MANAGEMENT UNIT PHENOLOGY | DATA COLLECTION

Management unit phenology data are collected on the date a burning event occurs and on the start and end dates of a grazing event. Thus, one phenology measurement is made for a burned unit and two measurements are made for a grazed unit. The observer spends 10-15 minutes walking around the management unit to get a feel for the average conditions across the unit, being sure to account for any natural variation that could influence phenology (e.g., soil moisture, slope). Note that the phenological cues that are observed and recorded will depend on the season of the treatment. For reference, photos and diagrams of grasses at various phenological stages are shown in Appendix A.

A data form for recording management unit phenology is provided in Appendix B. The cooperator will enter phenology data in the NPAM database along with their other management action data for the management unit.

Fall Treatments

For a fall treatment (applied between September 1 and December 31), the observer will monitor the phenology of the dominant warm-season native grasses and cool-season invasive grasses (both smooth brome and Kentucky bluegrass) at the management unit (reference photos are provided in Appendix A). The observer will make an ocular estimate of the following:

1. Whether the majority (>50%) of warm-season native grass plants at the unit are still actively growing or have gone to seed.
   Flowering and seed production will vary by species; focus on the dominant species at the site. The seed should be ripe and easy to remove by hand.
2. The percent of cool-season invasive grasses at the unit that are fall green-up plants.
   Fall green-up plants are fresh tillers that have started growing after a period of summer dormancy. During this stage, the fall green-up plants are usually a bright green to evergreen color. This category does not include plants that are in the process of senescence, which are a yellow or light green color, often with brown mottling.
3. The percent of cool-season invasive grasses at the unit that are completely senesced.
   Plants that have completely senesced will be completely brown in color. Late in the season, this category will include both spring and fall plants.

This information will allow the observer to classify the unit at the time of the management action into one of three fall phenological stages in the database:

1. >50% of warm-season native grasses are still active,
2. >50% of warm-season native grasses have gone to seed and >25% of cool-season invasive grasses are fall green-up plants, or
3. >50% of warm-season native grasses have gone to seed and >75% of cool-season invasive grasses have completely senesced.

Spring Treatments

For a spring treatment (applied between January 1 and August 31), the observer will monitor the phenology of smooth brome at the management unit (a leaf stage diagram is provided in Appendix A). The observer will make an ocular estimate of the following:

1. The percent of smooth brome at the unit that has at least 5 leaves.
   Count the number of leaves on several plants. The 5-leaf stage corresponds with tiller elongation, the most vulnerable stage for smooth brome in the spring.
2. The percent of smooth brome at the unit that has developed an inflorescence.
   A visible inflorescence corresponds with the end of tiller elongation.

This information will allow the observer to classify the unit at the time of the management action into one of three spring phenological stages in the database:

1. >50% of smooth brome has fewer than 5 leaves,
2. >50% of smooth brome has at least 5 leaves, but inflorescences are not yet visible, or
3. >50% of smooth brome inflorescences are visible or have already passed.

2. STATION-LEVEL PHENOLOGY

Whereas management-unit level phenology data are focused on capturing phenology at specific points in time (i.e., the start and end of treatment), the aim of station-level monitoring is to track the progression of phenology during the year. Station-level phenology data are sometimes referred to as "window watcher" data. Surveys will occur within a broader sampling timeframe that is likely to encompass the actual phenological window. Progression of phenology is quantified by recording the timeline of changes in phenological cues.

2.1 STATION-LEVEL PHENOLOGY | WHO COLLECTS DATA

Station-level phenology data (sometimes referred to as "window watcher" data) will be collected by tallgrass cooperators. If there are spatial gaps not being surveyed by NPAM participants, the project coordinator may solicit assistance from non-NPAM resource professionals. The project coordinator and advisory team will provide training and guidance as needed to ensure consistent, reliable data collection (typically this training will occur as part of the Field Activity Workshops). The same staff member (usually the biologist or manager) should collect phenological data within years and, ideally, among years.

2.2 STATION-LEVEL PHENOLOGY | WHERE TO COLLECT DATA

Station-level phenology sites are intended to help monitor phenological progression across the station and ultimately define the start and end of the fall and spring cool-season windows each year for the specific location. Some considerations for identifying a site to collect station-level phenological data include:

- The site should be native sod with some smooth brome and/or Kentucky bluegrass present.
- As much as possible, choose a site that is fairly representative of prairies across the station.
- The site should not have received a defoliation treatment within the last year, since this may affect phenological development.

- The site should be convenient to survey frequently. Most observers will use an area that is located at or very near to their office.
- The window watcher site does not need to be an NPAM management unit.
- Try to avoid other site-specific, unusual situations that may affect the plant community (e.g., unusual invasive species, extreme slopes or moisture conditions).

2.3 STATION-LEVEL PHENOLOGY | DATA COLLECTION

Station-level phenology observations are made at a 2-4 day interval during both a fall and a spring observation period (see below for definitions). The observer spends 10-15 minutes walking around the site, stopping at 5-10 different areas. When choosing the stops, the observer will account for any natural variation at the site that could influence phenology (e.g., soil moisture, slope). If the situation occurs where cool-season invasive grasses and warm-season native grasses are not evenly interspersed at the site, it may be necessary to have up to 10 stops for the fall survey; five to address the cool-season invasive grass senescence progression, and a separate five to address the warm-season native grass progression.

Each of the stops should be marked with a pin flag at the initial visit of each year. The observer will collect data at these marked areas throughout the season to allow for consistency of sampling. Within an approximately 1-m^2 plot at each of the five stops, the observer will make an ocular estimate of the phenological cues described below. Estimates at each stop will be made in 10% intervals (0-10, 10-20, 20-30, etc.). Note that the cues used to track progression of the cool-season window will differ by season. For reference, photos and diagrams of grasses at various phenological stages are shown in Appendix A.

Fall and spring data forms (Appendices C and D) are provided to record observations at each visit. The data forms include a request for the soil drainage of the selected site. To obtain this information, go to the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. On the main web soil survey page, define the area of interest, click on the soil map tab, and then click on the map unit name for the relevant soil. A pop-up box will open with a description for the map unit, including the drainage class, under Properties and Qualities. There are significant uncertainties about the phenology of grasses in the project area, including current unknowns as well as the potential effects of climate change. Any additional comments or observations about phenology, weather patterns, etc. at the site will be very helpful as the project continues in the future.

Submit observation data forms to the project coordinator via email or fax by July 15 each year. The project coordinator and database coordinator will enter the data into an Access database

and update the phenology models annually. The phenological data will be shared with cooperators and other supporters on an annual basis.

Fall Observation Period

During the fall observation period (approximately September 1 through freeze-up), the observer will monitor the phenology of the dominant warm-season native grasses and cool-season invasive grasses (both smooth brome and Kentucky bluegrass) at the site (reference photos are provided in Appendix A). At each stop, the observer will make an ocular estimate of the following:

1. The percent of warm-season native grass plants at the stop that has gone to seed.
   Flowering and seed production will vary by species; focus on the dominant species at the site. The seed should be ripe and easy to remove by hand.
2. The percent of cool-season invasive grasses at the stop that are fall green-up plants.
   Fall green-up plants are fresh tillers that have started growing after a period of summer dormancy. During this stage, the fall green-up plants are usually a bright green to evergreen color.
3. The percent of cool-season invasive grasses at the stop that are in the process of senescence.
   Plants in the process of senescence will be a yellow or light green color, often with brown mottling. Another way to think of this: Of the cool-season invasive grasses in the plot, what percent is between the lush green of fall green-up plants and the complete brown of the fully senesced plants. Early in the season, only the spring plants will be in this category; later in the season, this will include both spring and fall plants.
4. The percent of cool-season invasive grasses at the stop that are completely senesced.
   Plants that have completely senesced will be completely brown in color. Late in the season, this will include both spring and fall plants.

Note: The reference photos in Appendix A should help distinguish among the cool-season phenological stages listed in #2-#4 above. At a given stop, the percents assigned to the three cool-season phenology stages should sum to 100%.

At the end of the survey period, the project coordinator will summarize the observation data by identifying the dates when the following phenological stages occurred:

1. >50% of the dominant native warm-season grass plants at the site have gone to seed.
2. >25% of the cool-season invasive grasses at the site are composed of fall green-up plants.
3. >75% of the cool-season invasive grasses at the site have completely senesced.

Spring Observation Period

During the spring observation period (approximately April 15 through June 30), the observer will monitor the phenology of smooth brome at the site (a leaf stage diagram is provided in Appendix A). At each stop, the observer will make an ocular estimate of the following:

1. The percent of smooth brome at the stop that has at least 5 leaves.
   Count the number of leaves on several plants. The 5-leaf stage corresponds with tiller elongation, the most vulnerable stage for smooth brome in the spring.
2. The percent of smooth brome at the stop that has developed an inflorescence.
   A visible inflorescence corresponds with the end of tiller elongation.

At the end of the survey period, the project coordinator will summarize the observation data by identifying the dates when the following phenological stages occurred:

1. >50% of smooth brome plants at the site were at the 5 leaf stage.
2. >50% of smooth brome plants at the site had reached inflorescence.

3. LITUREATURE CITED

Sather, N. 1996. Element stewardship abstract for *Poa pratensis*, *Poa compressa*. The Nature Conservancy, Arlington, VA. 21 pp.

Willson, GD and J. Stubbendieck. 2000. A provisional model for smooth brome management in degraded tallgrass prairie. Ecological Restoration 18:34-38.

APPENDIX A – PHENOLOGY GUIDE

Fall – Fall Green-up Compared to Senescence

Fall green-up plants (freshly green)

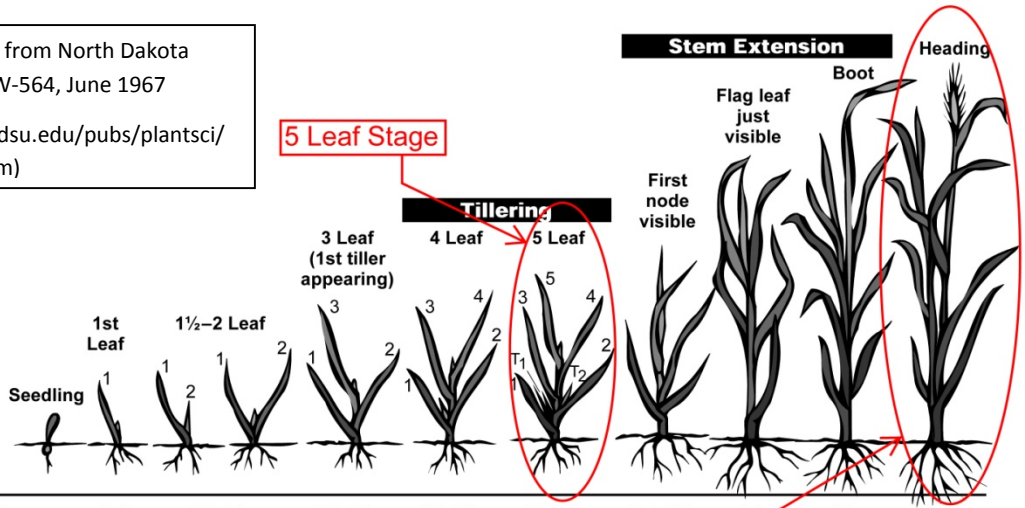
Grasses that are in the process of senescing (yellow, light green)

Grasses that have completely senesced (brown)

Spring – Leaf and Inflorescence Stages

Diagram modified from North Dakota State University, W-564, June 1967

(http://www.ag.ndsu.edu/pubs/plantsci/weeds/w564w.htm)



Early Planting (days)	7-8	14-16	20-22	26-28	31-33	34-36	44	53	58
Late Planting (days)	6-7	11-13	16-18	21-23	25-27	2			49
Growing Degree Day* (units)	72	144-215	358	501	644	715	1075	1359	1500

The lettering on the drawing represents the following: 1=1st leaf on the main stem of the plant; 2=2nd leaf on the main stem; 3=3rd leaf on the main stem; 4=4th leaf on the main stem; 5=5th leaf on the main stem and T=Tiller – not counted as a leaf when determining leaf stages.

Management Unit Phenology Data
USFWS Native Prairie Adaptive Management

Observer _____ Management Unit _____

Management Action (check one): ☐ BURN ☐ GRAZE

Date management started: _____ Date management ended: _____

Fall Treatment (applied between September 1 and December 31)

Phenology on day of burn or start of graze:

Warm-season native grasses (check one):
☐ > 50% of warm-season native grasses are still active
☐ > 50% of warm-season native grasses have gone to seed
Cool-season invasive grasses (check one):
☐ < 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 75% of smooth brome and/or Kentucky bluegrass has completely senesced (i.e., brown in color)

Phenology at end of graze:

Warm-season native grasses (check one):
☐ > 50% of warm-season native grasses are still active
☐ > 50% of warm-season native grasses have gone to seed
Cool-season invasive grasses (check one):
☐ < 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 25% of smooth brome and/or Kentucky bluegrass are fall green-up plants
☐ > 75% of smooth brome and/or Kentucky bluegrass has completely senesced (i.e., brown in color)

Comments:

Management Unit Phenology Data
USFWS Native Prairie Adaptive Management

Observer _____ Management Unit _____

Management Action (check one): ☐ BURN ☐ GRAZE

Date management started: _____ Date management ended: _____

Spring Treatment (applied between January 1 and August 31)

Phenology on day of burn or start of graze:

Smooth brome leaf stage (check one):
☐ > 50% of smooth brome has fewer than 5 leaves
☐ > 50% of smooth brome has at least 5 leaves
Smooth brome inflorescence (check one):
☐ > 50% of smooth brome is not yet showing inflorescences
☐ > 50% of smooth brome is showing inflorescences

Phenology at end of graze:

Smooth brome leaf stage (check one):
☐ > 50% of smooth brome has fewer than 5 leaves
☐ > 50% of smooth brome has at least 5 leaves
Smooth brome inflorescence (check one):
☐ > 50% of smooth brome is not yet showing inflorescences
☐ > 50% of smooth brome is showing inflorescences

Comments:

APPENDIX C

Station-Level Phenology – Fall Data
USFWS Native Prairie Adaptive Management

Observer _____ Phone _____ Email _____

Site Name _____

Legal Description: State _____ County _____ Township _____ Range _____ Section _____ Quarter _____

Soil drainage class (check one): ☐ Poorly Drained ☐ Moderately Drained ☐ Well Drained http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Date	% of dominant warm-season native grasses that have gone to seed					% of cool-season invasive grasses that are fall green-up plants (freshly green)					% of cool-season invasive grasses that are in the process of senescing (yellow, light green)					% of cool-season invasive grasses that have completely senesced (brown)				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)																			
Stop #→	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Example 9/1/2012	Example 80-90	70-80	80-90	70-80	70-80	Example 0-10	10-20	10-20	0-10	10-20	Example 70-80	60-70	60-70	70-80	60-70	Example 0-10	10-20	0-10	0-10	0-10

APPENDIX C

Date	% of dominant warm-season native grasses that have gone to seed					% of cool-season invasive grasses that are fall green-up plants (freshly green)					% of cool-season invasive grasses that are in the process of senescing (yellow, light green)					% of cool-season invasive grasses that have completely senesced (brown)				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)																			
Stop #→	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Comments:

APPENDIX D

Station-Level Phenology – Spring Data
USFWS Native Prairie Adaptive Management

Observer _____ Phone _____ Email _____

Site Name _____

Legal Description: State _____ County _____ Township _____ Range _____ Section _____ Quarter _____

Soil drainage class (check one): ☐ Poorly Drained ☐ Moderately Drained ☐ Well Drained http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Date	% of smooth brome with at least 5 leaves					% of smooth brome with an inflorescence				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)									
Stop #→	1	2	3	4	5	1	2	3	4	5
Example 4/15/2012	20-30	30-40	Example 30-40	20-30	30-40	0-10	0-10	Example 0-10	0-10	0-10

APPENDIX D

Date	% of smooth brome with at least 5 leaves					% of smooth brome with an inflorescence				
	(Use Intervals: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90, 90-100)									
Stop #→	1	2	3	4	5	1	2	3	4	5

Comments: