Manitoba's Rangeland Plant Communities of the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions

A First Approximation

Prepared For Manitoba Forage and Grassland Association
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http://mfga.net/projects/current-projects/manitoba-ecosite-and-rangeland-health-initiative/

Executive Summary

The first approximation of this guide attempts to summarize the plant communities that are expected to occur on rangelands within Manitoba's Aspen Parkland and Assiniboine Delta Rangeland Ecoregions. These rangeland ecoregions make up most of the area west of the Manitoba Escarpment, except for some higher elevation rangeland ecoregions. The Mid-Boreal Uplands and Transition Rangeland Ecoregion that includes the area in and around Riding Mountain National Park and Duck Mountain Provincial Park, and the Southwest Manitoba Uplands Rangeland Ecoregion were not included, but this document may still be useful for the grasslands existing there. This guide is expected to help users understand native rangeland plant communities in western Manitoba, and it is a requirement for using the Manitoba Range and Pasture Health Assessment Workbook.

Using field data and observations, we identified and described plant communities across selected ecosites (ie. Loam, Moist Loam, Sand, Moist Sand, Dunes, Clay, Eroded Slopes and Wet Meadow) within the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions. The series of plant communities for each ecosite are introduced with one or more state and transition (S&T) diagrams summarizing the different plant communities that could occur on a given ecosite and the expected transitions from one plant community to another, showing how plant communities respond to natural succession, growing conditions, natural and human disturbances and idleness. The S&T diagrams for each rangeland ecosite are followed by detailed descriptions of each plant community.

Each rangeland ecosite has one or more reference plant communities (RPC). These are the late seral communities that would establish on an ecosite under current climatic conditions, with minimal disturbance. The area covered by the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions is geographically large, with changes in latitude and elevation. Thus, there may be multiple RPCs suggested for each rangeland ecosite. This guide includes potential RPCs and transitional plant communities (i.e. early to mid seral) which are supported by currently available data. Each plant community description consists of lists of plant species and their relative and/or absolute abundances. Additional data included are total herbaceous cover, litter cover, soil exposure, moss and lichen cover, species richness and diversity measures, exotic content, and expected average forage productivity. A paragraph describing the general composition of each plant community is also included.

There are plentiful gaps in available data used for this document, so in many cases a theoretical plant community is shown in the S&T diagram to help explain successional or disturbance trajectories. Theoretical reference plant communities are described qualitatively based on the decreaser plant species found in their related mid and early seral communities, or general field observations.

Data sources and methods of analysis are presented in the introductory section of this guide. Post-hoc non-metric multi-dimensional scaling (NMDS) ordinations to aid in visualizing the diversity of the data, trends within it, and the cohesiveness of plant communities are presented in the Appendix C.

Acknowledgements

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Contributions of Authors and Editors

Plant community analysis and writing were completed by Lysandra Pyle. Mae Elsinger and Kerry LaForge contributed guidance and made significant contributions to writing and editing. Jane Thornton, Jeff Thorpe, Jordan Becker, Rachel Whidden, Rafael Otfinowski, and Rebekah Neufeld reviewed draft versions of the document.

Photo and Figure Credits

Lysandra Pyle: Plant communities.

Mae Elsinger: Cover photo and plant communities.

Jeff Thorpe: Rangeland ecoregion and ecosite maps.

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1. Introduction

Determining the potential native plant communities that occur among Manitoba's rangelands is one of the key building blocks of sustainable rangeland management. Native plant communities have developed under such variables as climate, soils, topography and historical influences such as fire and grazing, resulting in plant communities that are distinctly different from one another in terms of relative plant species abundances, productivity and management requirements. These plant communities continue to change over time, responding to annual growing conditions, natural disturbances (fire, herbivory, and extreme weather events), and human influences (livestock grazing, cultivation, industrial development, or suppression of fire or grazing).

Providing land managers with a native plant community classification and descriptions can aid in rangeland management planning, setting stocking rates, targeting grazing pressure, determining range health, mapping wildlife habitats, and determining restoration targets. *Manitoba's Rangeland Plant Communities of the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions* presents the expected plant community types found within the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions of Manitoba. State and Transition (S&T) Diagrams summarize the different plant communities that could occur on a given ecosite (further described below), and the expected transitions from one plant community to another. However, this document is continually evolving as more data is collected: the user must realise that the plant community descriptions do not represent all possible plant communities but those which were best supported by current data and observations.

2. Rangeland Ecoregions

Ecoregions are defined by environmental conditions (climate) and geomorphology (physical features of the earth's surface). Our rangeland ecoregions have slightly different delineations compared to *A National Ecological Framework for Canada* (Ecological Stratification Working Group 1996), which is currently in use by Manitoba Sustainable Development. Manitoba's Rangeland Ecoregion boundaries are a hybrid between the Ecoregion classification and the Natural Regions classification formerly used by Manitoba Parks and Protected Areas (Manitoba's Protected Areas Initiative 2007). The focus of this *Manitoba's Rangeland Plant Communities* document is the Aspen Parkland and Assiniboine Delta (APAD) Rangeland Ecoregions. The following descriptions for these were based on those in the *Rangeland Classification for Agri-Manitoba* (Thorpe 2014) report. Please refer to the document for complete description of these and other rangeland ecoregions.

Aspen Parkland (AP) Rangeland Ecoregion

The Aspen Parkland covers much of the area west of the Manitoba Escarpment, but excluding the Mid-Boreal Uplands and Transition Rangeland Ecoregion (in and around Riding Mountain National Park and Duck Mountain Provincial Park), the Southwest Manitoba Uplands Rangeland Ecoregion (Pembina Hills and Turtle Mountain), and the Assiniboine Delta Rangeland Ecoregion. This is the driest climate in Manitoba, and therefore most geared towards grasslands instead of forests. The Aspen Parkland falls within the black soil zone which is typically comprised of Orthic Black Chernozems, mainly on loamy soil but there are some large sandy areas deposited by glacial meltwaters. Prior to European settlement, soils in the region supported productive plant communities in a mosaic of Aspen woodlands and grassland, but most has been converted to cropland and tame forages (Thorpe 2014).

Assiniboine Delta (AD) Rangeland Ecoregion

The Assiniboine Delta falls within the Aspen Parkland Ecoregion, as defined in *A National Ecological Framework for Canada* (Ecological Stratification Working Group 1996) but is identified as a separate natural region in the *Manitoba's Natural Regions Map* (Manitoba's Protected Areas Initiative 2007). In creating the rangeland ecoregions classification (Thorpe 2014), the steering committee decided to separate it from the Aspen Parkland Rangeland Ecoregion, as it represents a geologically and ecologically distinct area. It is distinguished from the Aspen Parkland by a large sandy delta where sediments from the Assiniboine River settled out onto the shore of Glacial Lake Agassiz. Since glacial retreat, much of the sediment was worked up by wind into dunes, and then stabilized, except for approximately 10 km^2 of active dunes. The two most common soils are Black Regosols resulting from dune formation, and Black Chernozems in stabilized grasslands. Rough topography and coarse soil texture have discouraged cultivation over a significant amount of the region, making it a significant area of native vegetation (Thorpe 2014).

Image 1. Example of a plains rough fescue (*Festuca hallii*) and porcupine-grass (*Hesperostipa curtiseta*) plant community assemblage on a Sand ecosite in the Aspen Parkland.

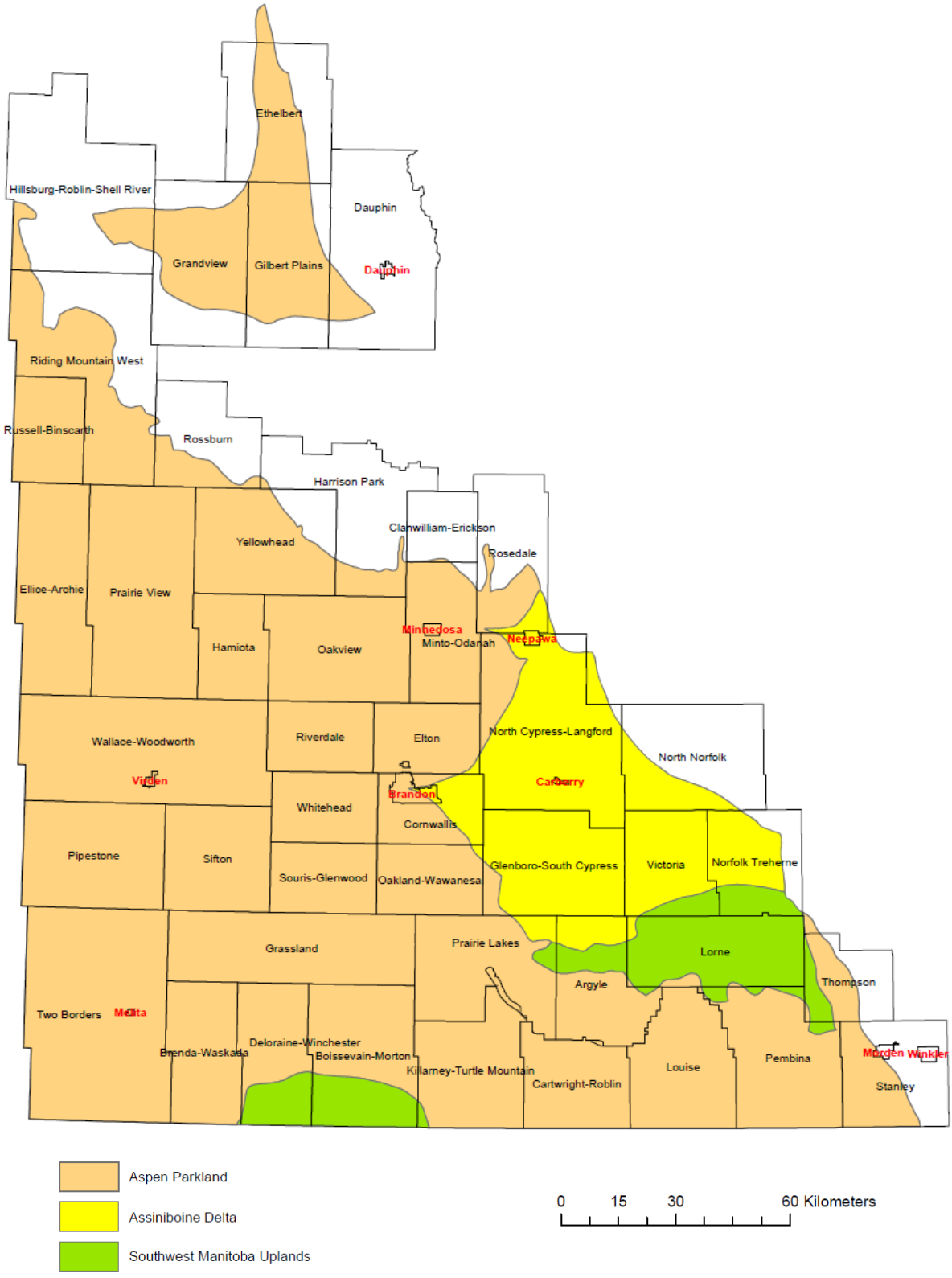


Figure 1. Map of the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions (Thorpe 2017).

3. Ecosites

Within the large area of rangeland ecoregions, which are based on broad climate patterns and geological history, are site-specific areas called **ecosites** (shortened from ecological sites). The Society for Range Management (1998) defines an ecological site as "a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation". In Manitoba, ecosites are differentiated from one another by soil and landscape characteristics which include soil texture, drainage, slope, proximity to bedrock, and degree of salinity or calcareousness. These physical characteristics influence plant community and soil responses to disturbance and further distinguish ecosite.

Of the 21 known rangeland ecosites for Agri-Manitoba, 12 common ecosites (for which plant community data exists) are briefly described below. This *Manitoba's Rangeland Plant Communities* guide describes plant communities for selected ecosites (identified with *).

For a detailed guide to identifying ecosites based on soil texture, drainage, and other factors, refer to *Rangeland Classification for Agri-Manitoba* (Thorpe 2014). Detailed PDF maps of the dominant rangeland ecosites have been developed for municipalities in the Aspen Parkland and Assiniboine Delta. A GIS layer was also created of the ecosites expected for any location in Agri-Manitoba. These products are to be posted on the Manitoba Forage and Grassland Association website.

***Loam (LM)**

Well drained uplands with loam, silty loam, and clay loam textured soils.

***Moist Loam (ML)**

Imperfectly drained soils with loamy texture (including clay loam, sandy loam or silty loam). Evidence of temporary saturation by water (red and gray mottles) within 50 cm of the soil surface.

***Clay (CY)**

Well drained to imperfectly drained soils with clay to heavy clay texture.

Sandy Loam (SL)

Well drained uplands with sandy loam soil texture.

***Sand (SD)**

Rapidly drained to well drained uplands with coarser textured soils (loamy sand, sand, finer gravel), which lack the hills and ridges found in the dunes ecosite.

***Dunes (DN)**

Sand deposits shaped into hills and ridges by wind.

***Moist Sand (MS)**

Imperfectly drained coarse-textured soils including gravel and sandy loams. Evidence of temporary saturation by water (red and gray mottles) within 50 cm of the soil surface.

***Eroded Slopes (ER)**

Well drained, steep slopes of various soil textures. High rates of water erosion result in thin soil profiles.

Alluvium (AL)

Imperfectly drained soils on recent alluvial deposits along the flood plains of rivers and streams. There may be evidence of temporary saturation by water (red and gray mottles) within 50 cm of the soil surface.

Moist Saline (SAL)

Imperfectly drained depressional areas that are moderately to strongly saline. Evidence of temporary saturation by water (red and gray mottles) within 50 cm of the soil surface.

***Wet Meadow (WM)**

Lowland sites typically flooded for only a few weeks in the spring but remain saturated throughout the summer within 50 cm of the soil surface. Poorly drained Gleysolic soils, characterized by dull gray mineral soils.

Shallow Marsh (SHM)

Wetlands that are flooded until mid-summer (July or August). Poorly drained Gleysolic soils.

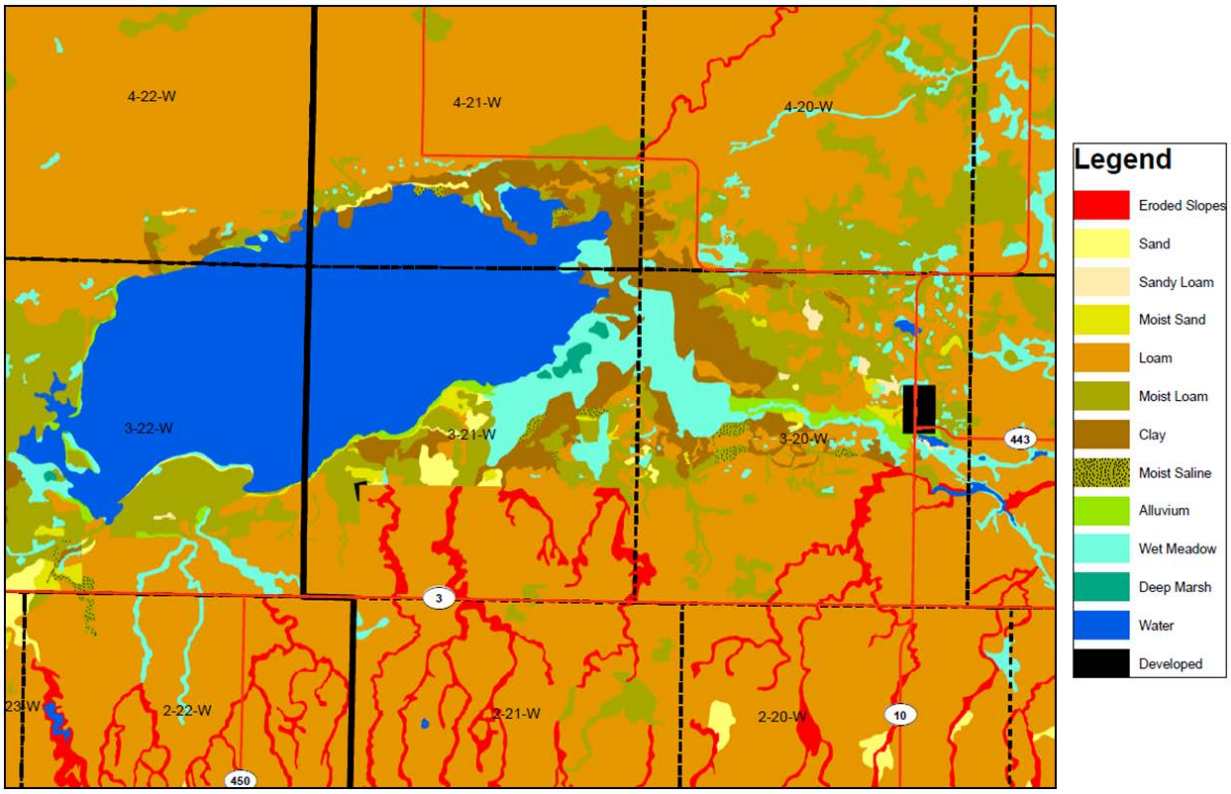


Figure 2. Example of an ecosite map, adapted from Thorpe (2017). These are the dominant ecosites near Whitewater Lake north of the Turtle Mountains in southwestern Manitoba's Aspen Parkland.

4. Plant Communities

4.1. Plant Community States and Transitions

Ecoregions and ecosites can support many different types of plant communities. The observed plant communities are affected by the growing conditions (soil, topography, moisture availability, chemistry), and by natural and human influences (e.g. grazing, lack of grazing, prolonged drought, excessive rainfall, exotic species invasion, burning, timber removal, industrial disturbances, or suppression of fire). All of this variability in growing conditions and site history results in a number of possible plant communities for any given ecosite.

A **reference plant community** (RPC; formally understood as **climax** under Clementsian succession theory) is one that would become established on an ecosite under current climatic conditions with minimal disturbance (e.g. light grazing pressure). A RPC is characterized by dominance of productive decreaser plants (those that decrease with continued heavy disturbance), low abundance of increaser plants (those that increase with disturbance), and minimal content of non-native plants. See Appendix B for examples of decreasers, increasers, and non-native invaders.

Plant communities can move or **transition** along pathways, back and forth among different **states** (i.e. **early seral**, **mid-seral**, **late seral** and **RPC)**, depending on the type and degree of disturbance. Some changes are reversible and can move a disturbed plant community back towards the reference plant community. Sometimes the changes result in **stable states** that are relatively resistant to recovery. A third alternative is for a plant community to move along a different pathway towards a new RPC that is unlike the original RPC.

The plant communities presented in this guide do not represent all possible communities but those types which were best supported by local data and observations. To understand where an observed plant community falls within a successional pathway on a particular ecosite type, State and Transition (S&T) diagrams are used to show the potential reference plant communities (RPCs), transitional communities, and the potential transitions among them.

4.2. Rangeland Plant Community Dynamics in Southwestern Manitoba

Manitoba is a unique growing environment among the Prairie Provinces for many reasons:

- Proximity to large water bodies influences climate.
- High amounts of precipitation throughout year, and few summer moisture deficits make it highly productive and supportive of plants requiring moister environments.
- Low elevation and plentiful available water result in land influenced by ground water.
- Being a transition area at the edges of many high-level plant community assemblages (Tallgrass, Mixedgrass, Fescue, Boreal Forest) results in unique mixtures of dominant plants (e.g. rough fescue with porcupine grass; porcupine grass with big bluestem).
- A complex patchwork of geological landforms and soil parent material within the grassland area of the province (e.g. glacial till, elevated Manitoba Escarpment, sandy remnants of Glacial Lake Agassiz and other glacial lakes, Lake Manitoba and Interlake Plains, Red River Valley) creates patchy growing conditions for a complex mosaic of plant community assemblages.
- Earlier initiation of settlement combined with moist and fertile soils means a long-term interaction of rangelands with non-native plant species.

Native grasslands in the Aspen Parkland and Assiniboine Delta are diverse plant communities that provide a suite of ecological services from carbon storage, nutrient cycling, forage production, biodiversity, pollination, and wildlife habitat (Havstad et al. 2007). European settlement of southern Manitoba's grasslands started in the early 1800s, and since then the grasslands have been shaped by agricultural land uses and invasion by exotic species. Thus, the historical distribution and composition of plant communities is relatively unknown (Henderson and Koper 2014; Wilson and Belcher 1989). Further, there is less literature describing the influence of rangeland management practices on plant communities, soils, and productivity on southwestern Manitoba's grasslands when compared to adjacent provinces and states. The plant communities described in this *Manitoba's Rangeland Plant Communities* guide offer some of the first insights into potential grassland plant community dynamics across diverse ecosites in the ecologically unique and sensitive grasslands of Manitoba.

Grassland reference plant communities (RPCs) differ among ecosites, and different plant species dominate as a result of differences in climate (primarily precipitation, evaporation, and available soil water). Plains rough fescue was typically associated with reference communities for a diversity of ecosites with well-drained soils like sand and loam, which is typical of the black soil zone and the cool moist climate (Coupland and Brayshaw 1953; Looman 1968). Other RPCs were dominated by spear grasses like western porcupine-grass (*Hesperostipa curtiseta*) and porcupine-grass (*Hesperostipa spartea*) often in association with fescue. In Manitoba, Western porcupine-grass dominates relatively xeric grasslands in the southwestern corner, with porcupine-grass becoming more dominant towards the north and east.

Dominance and co-occurrence of warm season grasses like little bluestem (*S. scoparium*) and prairie dropseed (*Sporobolus heterolepis*) coinciding with plains rough fescue, is unique to Manitoba. The pattern of abundant warm-season grasses in plant communities expected to be dominated by cool-season grasses is suspected to result from brief spring-time biomass reduction (whether by fire or grazing), followed by adequate rest and favourable weather, as indicated in limited studies and observations on community pastures (Elsinger et al. 2016). Fire also has been shown to increase tillering of little bluestem (Limb et al. 2011).

On coarse textured ecosites (Sand, Moist Sand and Dunes), especially within the Assiniboine Delta Rangeland Ecoregion, there tends to be greater representation of warm season grasses like bluestems (*Andropogon* spp. and *Schizachyrium scoparium*) and other species more typical of tallgrass prairie. These sandhill prairies could be tallgrass prairie remnants from a historical range that was determined to extend as far west as eastern Saskatchewan, particularly along banks of the Assiniboine, Qu'Appelle, Pembina, and Souris Rivers (Henderson and Koper 2014). These ecosites often have plant communities with high amounts of creeping juniper (*Juniperus horizontalis*). Creeping juniper is a prostrate shrub that colonizes disturbed soils and likely increases with fire suppression, recovery from heavy grazing and other surficial disturbances. Creeping juniper was associated with plains rough fescue on sandy prairie, as it likely harbours seed, and protects fescue seedlings and mature plants from grazing.

Forests in the Aspen Parkland are typically dominated by trembling aspen (*Populus tremuloides*), with bur oak (*Quercus macrocarpus*) comprising pockets, mainly along river valleys and in areas of higher elevation (such as the Brandon Hills, Turtle Mountains and Pembina Hills). Aspen is known to encroach on grassland (Bailey and Wroe 1974; Widenmaier and Strong 2010). Historically grasslands were maintained by natural disturbances that prevented the encroachment of woody vegetation through seasonal grazing by bison and periodic fire (Archibold et al. 2003; Bailey and Wroe 1974). Its advance

appears to be accelerated by lack of fire or grazing on habitat preserves in Manitoba as well as high available soil moisture. Wild ungulates have been largely replaced with cattle, which can impede woody growth but not as effectively as elk and bison (Bork et al. 2013), and fire tends to remain underutilized in land management due to concerns of damage or costly liability insurance.

Livestock grazing continues to be an important modern alternative, if guided by beneficial management practices, for maintaining plant community ecological function, heterogeneity, and biodiversity. All disturbances, including grazing, affect grassland ecosystems via their intensity, timing, and frequency. There is a multitude of grazing systems that allow for flexibility in managing these 3 key aspects of disturbance for fighting undesirable vegetation, maintaining high quality native grasslands, or shifting an existing plant community towards a more desirable one. Disturbances can have the wrong intensity, timing, and/or frequency, resulting in undesirable effects on a grassland ecosystem. This can be in the form of a fire at the wrong time, grazing for too long of a period, or grazing too hard without adequate amount of time for recovery (Reed et al. 1999). The result may be reduced competitiveness of decreaser plants like plains rough fescue and needle grasses, providing opportunities for relatively short native grasses like blue grama (*Bouteloua gracilis*) to increase, or non-native grasses like Kentucky bluegrass (*Poa pratensis*) to take hold and outcompete desirable native plant species (Abouguendia 1990). Non-native cool season grasses can persist when disturbance is removed (Sinkins and Otfinowski 2012), resulting in altered plant communities (Vujnovic et al. 2000). In other provinces, restoration of rough fescue, a key late-seral grass found in Manitoba, has proven difficult (Desserud and Naeth 2013; Elsinger 2009), so management must strive to prevent the loss of such species.

5. How to Use This Guide

5.1. Uses of the Guide

This *Manitoba's Rangeland Plant Communities* guide provides plant community descriptions and State and Transition (S&T) diagrams, depicting successional relationships and potential transitions among plant communities within each ecosite. This document is useful as a stand-alone guide, by livestock producers and land managers, to determine what type of rangeland plant communities they have, what its typical forage productivity and livestock carrying capacity are, and how to set restoration and management targets. It can also provide the necessary reference plant community descriptions required to evaluate range health or the status of reclamation or restoration efforts using **Manitoba's Range and Pasture Health Assessment** method.

The Manitoba Range and Pasture Health assessment is a science-based procedure, modelled on the Alberta method, with some modifications for Manitoba conditions. The method is a package containing three components (including this guide):

1. Ecosite identification tools found in *Rangeland Classification for Agri-Manitoba* (Thorpe 2014), and ecosite identification PDF maps or GIS data ((Manitoba Forage and Grassland Association 2017)
2. Plant community descriptions by ecosite in *Manitoba's Rangeland Plant Communities of the Aspen Parkland and Assiniboine Delta Rangeland Ecoregions* (Pyle et al. 2018)
3. Range and pasture health assessment form and procedure in *Manitoba Range and Pasture Health Assessment Workbook* (Manitoba Forage and Grassland Association 2017)

To successfully use Manitoba's Range and Pasture Health Assessment, all three components must be applied. These documents, plus helpful ecosite maps and GIS layers, are to be posted on the Manitoba Forage and Grassland Association's website.

5.2. Ecosite Identification

Whether using this guide to identify and understand an observed rangeland plant community, or to evaluate range health, the first thing a user must do is identify the ecosite of the location in question. Bear in mind that the landscape is complex, and that a land unit may have multiple ecosites. Ecosites are derived by landscape features, soil texture and other local edaphic factors such as soil moisture, carbonates, salinity, and alkalinity. The best way to identify ecosites is in the field, using the instructions in the *Rangeland Classification for Agri-Manitoba* report to make a decision based on observations of soil, water table, topography, and indicator plants. Preliminary identification of potential ecosites can be done with the PDF maps that show the dominant ecosite for a location, or the GIS map layer that shows up to 3 possible ecosites for a location. These products are to be posted on the Manitoba Forage and Grassland Association website. Ground truthing is required, due to the limitations of the data going into the maps. Once the appropriate ecosite has been selected, refer to the State and Transition diagram[1] for that ecosite found within this guide.

5.3. Plant Community Observations and Identification

Plant community observations or data collection should occur within a uniform and representative area (relatively consistent ecosite, management history, and general plant community composition). Recommended plant community survey methods are described in the *Manitoba Range and Pasture Health Assessment Workbook* (Manitoba Forage and Grassland Association 2017). This *Manitoba's Rangeland Plant Communities* guide is meant to describe separate individual plant community types, not an amalgamation of different plant communities from a heterogeneous landscape (i.e. combined ecosites and/or combined forest, shrub, wetland and/or grassland areas). It is possible for a parcel or management unit (e.g. a pasture, grazing lease, ranch, or ecological reserve) to contain multiple ecosites (e.g. upland Loam Ecosite vs. lowland Wet Meadow Ecosite) or plant communities in different levels of utilization (i.e. fields grazed at different intensities or different times of year). Identifying plant communities separately for different ecosites (i.e. upland Loam Ecosite and lowland Wet Meadow Ecosite) or different management units (e.g. calving pasture vs. mid-summer pasture) can help with planning and build an understanding of the management impacts across the landscape.

5.4. Range and Pasture Health Assessment

Once the correct ecosite has been identified for a location, a range and pasture health assessment can be completed. The observed plant community composition, structure, bare soil, and litter amounts must be compared to those for the expected reference plant community (RPC) of that ecosite. The difference in species composition, structure, soil exposure, and litter amounts between the observed plant community and the reference plant community illustrates the effects of land management practices, and the ability for the plant community to perform key ecological functions. Note that there are cases where descriptions of

[1] Describe how plant communities shift along gradients such as disturbance (i.e. fire, grazing, etc.), moisture, and other factors. Shifts in plant communities are not necessarily linear, communities can often switch between states depending on management and disturbance history. Thresholds can occur where communities cannot transition back to previous states (e.g. persistence of Kentucky bluegrass in disturbed fescue prairie).

soil exposure and ground cover may be absent or represented by few samples and should be interpreted with caution.

Plant community composition conveys valuable information on the ecological integrity and function of a vegetation stand. Later seral plant communities are superior in capturing solar energy efficiently, in cycling organic matter and nutrients, retaining moisture, supporting wildlife habitat and in providing the highest potential productivity. Healthy functioning rangelands are usually achieved with a plant community composition that is similar to, or with minor alteration from, that of the reference plant community

Alteration of a native grassland by non-native species can form a **Modified Plant Community**, whose Integrity and Ecological Status Indicator will be measured on a different scale than if it were considered a native grassland community. A Modified plant community is defined as containing > 50% (relative biomass or cover) from non-native plant species. Such communities generally have two origins:

1. Historical attempts to convert the land to annual crops or forage production, resulting in a stand dominated by non-native perennial forages (i.e. crested wheatgrass, intermediate wheatgrass, smooth brome, Canada bluegrass, alfalfa, sweet clover); or

2. Undesirable non-native species invasion (usually by Kentucky bluegrass or smooth brome).

Some modified plant communities remain dominated by non-native species and may represent new stable states where native propagules have been depleted and the competitive ability of native plants has been compromised. In some cases, a modified plant community can recover, when the native species regain dominance. These typically include dominance by a decreaser species like porcupine-grass (*Hesperostipa spartea*) or big bluestem (*Andropogon gerardii*), followed by non-native grasses like Kentucky bluegrass (*Poa pratensis*). This recovery may be due to sufficient live plants or propagules of key decreaser species in the modified plant community and adjustment of land management practices (i.e. season-long grazing changed to twice-over rotational grazing in the 1990s).

5.5. Dealing with Incomplete Reference Information

It is important to note that this plant community guide is the first approximation for Manitoba's Aspen Parkland and Assiniboine Delta Rangeland Ecoregions and thus, all plant community types expected for these regions have not been described. If there is no close match between an observed plant community and one described in this guide, then some interpretation of where the new plant community falls within a disturbance gradient may be requiredThe observer can determine the observed plant community's ecological status by evaluating the relative abundances of decreasers, increasers and exotic invaders. A later-seral or reference plant community has greater cover or biomass of decreasers (plants that decrease with prolonged disturbance), than it does increasers (those that exist naturally in small amounts but increase with prolonged disturbance). In grasslands, decreasers are often productive grass species like plains rough fescue (*Festuca hallii*), porcupine-grass (*Hesperostipa spartea* or *H. curtiseta*), or big bluestem (*Andropogon gerardii*). In poorly drained lowlands, decreasers like wetland sedges or reed grasses (*Calamagrostis* spp.) would be expected in the RPCs. In woodlands, palatable shrubs like saskatoon (*Amelanchier alnifolia*) or chokecherry (*Prunus virginiana*) and herbaceous plants that decline with ungulate disturbance would be expected in a later seral community (Bork et al. 2013). A full table describing major grasses, forbs and shrubs, and their status as decreaser, increaser or invader, is in Appendix B.

5.6. Productivity, Plant Litter Amounts, and Sustainable Stocking Rates

At this point, data on plant community productivity and beneficial plant litter amounts for Manitoba's range and pasture land is limited. When available, dry weights of available forage (kg/ha) are provided. Litter cover is provided (as a percentage of total ground cover), but not the biomass amounts (kg/ha) that are required by the Range and Pasture Health Assessment Workbook. Recommended initial stocking rates will not be provided at this time.

6. Methods and Analysis

Plant community data were collected from numerous locations by various authorities, using various survey methods. Due to a shortage of Aspen Parkland and Assiniboine Delta Rangeland Ecoregion datasets, data from adjacent rangeland ecoregions in Saskatchewan (eastern part of Moist Mixed Grassland, Aspen Parkland) and Manitoba (Mid-Boreal Upland and Transition, Aspen/Oak Parkland) were used with discretion. Most data were provided by Agriculture and Agri-Food Canada from their work on community pastures and various research projects (including the Manitoba Forage Benchmarking Project) on wildlife management areas, privately owned grazing land, and Crown grazing leases. Parks Canada allowed us to use data gathered on grasslands at Riding Mountain National Park. Manitoba Sustainable Development provided data for Wildlife Management Areas and Provincial Parks. Data from Nature Conservancy properties were also used with permission from NCC, and Saskatchewan Research Council furnished additional data from unspecified locations to help fill in gaps in the dataset.

Raw plant community data included in the analysis were collected in 3 ways:

1. Visual estimate of **relative** abundance (total = 100%) of individual species by cover (area) or biomass (volumetric) present in a quadrat, from 5 or more points along a transect.
2. Visual estimate of **absolute** cover (total ≠ 100%) of individual species within a quadrat.
3. Percent frequency of individual species intercepting multiple predetermined points along atransect (frequency was considered analogous to **absolute** cover; typically > 100).

Sampling intensity (numbers of quadrats or transects) was variable among the methods used and between data sets. In some cases, individual transect data was lacking (i.e. Wildlife Management Areas), but averaged values describing plant communities were extracted. A standard unit of observation (n) was typically the averaged values from a transect, or treatment within site (for data extracted from research).

Sampling locations were assigned an ecosite based on infield observations (one or more of topography, soil texture, and proximity to the soil water table). In cases where this information was lacking, soil and ecosite maps were used in ArcMap to assign ecosites. Such a desktop assignment is at risk of errors due to the coarse nature of the Manitoba Soil Survey (which is the basis for ecosite maps), so some judgement based on species composition and indicators was often applied. For example, a single soil survey polygon may have well drained, imperfectly drained, and poorly drained members of a loamy soil association. Further information (soil sample information, photos, remote sensing imagery and/or indicator species) is required to more accurately assign the appropriate Loam, Moist Loam, or Wet Meadow Ecosite, respectively.

Merging datasets required standardizing the nomenclature of species and scrutinizing the data for potential observer errors (misidentified species and quality of the data). Species names were updated using Canadensys (Brouillet et al. 2017) and the USDA Plants Database when species were not present in

Canadensys. Prior to cluster analysis, all plant community data was standardized to relative abundance (i.e. absolute abundance values were adjusted to total 100%), providing the ability to analyze all data sets in unison using multivariate analytical methods.

In R software (R Core Team 2017), the plant community data matrices were analyzed using the *vegdist* and *metaMDS* functions in the *vegan* package (Oksanen et al. 2017). Similarity between all plant communities was analyzed using the Bray-Curtis distance metric (a similarity index suited to zero-inflated community matrices). Function *vegdist* calculated the similarity of sampling units (n) prior to producing cluster dendrograms using the function *hclust*. Function *metaMDS* was used to produce NMDS (non-metric multidimensional scaling) ordinations for each ecosite, aiding in the interpretation of plant community gradients.

After the plant community clusters were determined, a supervised approach was used to finalize the assignments. To aid in the interpretation of clustering results, ranks of the 5 most abundant herbaceous and 5 woody species were tabulated. A successional index was also used to identify later seral clusters. Other variables used in the interpretation of plant community data included the proportion of non-native species like Kentucky bluegrass (*Poa pratensis*), woody species, and decreaser graminoids. Where ground cover was recorded (litter, bare ground, etc.) inferences about grazing intensity could be made. Clustering results were then observed for trends in the rank of increaser and decreaser species. Overall clustering typically partitioned out plant communities based on ecosite. Different ecosites tended to express their own plant community assemblages and unique indicator species.

State and Transition Diagrams (S&Ts) were guided by NMDS, similarity in plant communities, and prior knowledge of plant community types and shifts grounded in field observations and published literature (Kupsch et al. 2013; Thorpe 2014; Willms et al. 1985). Several theoretical plant communities were created, based on key species within the descriptions of other plant communities in the same successional trajectory.

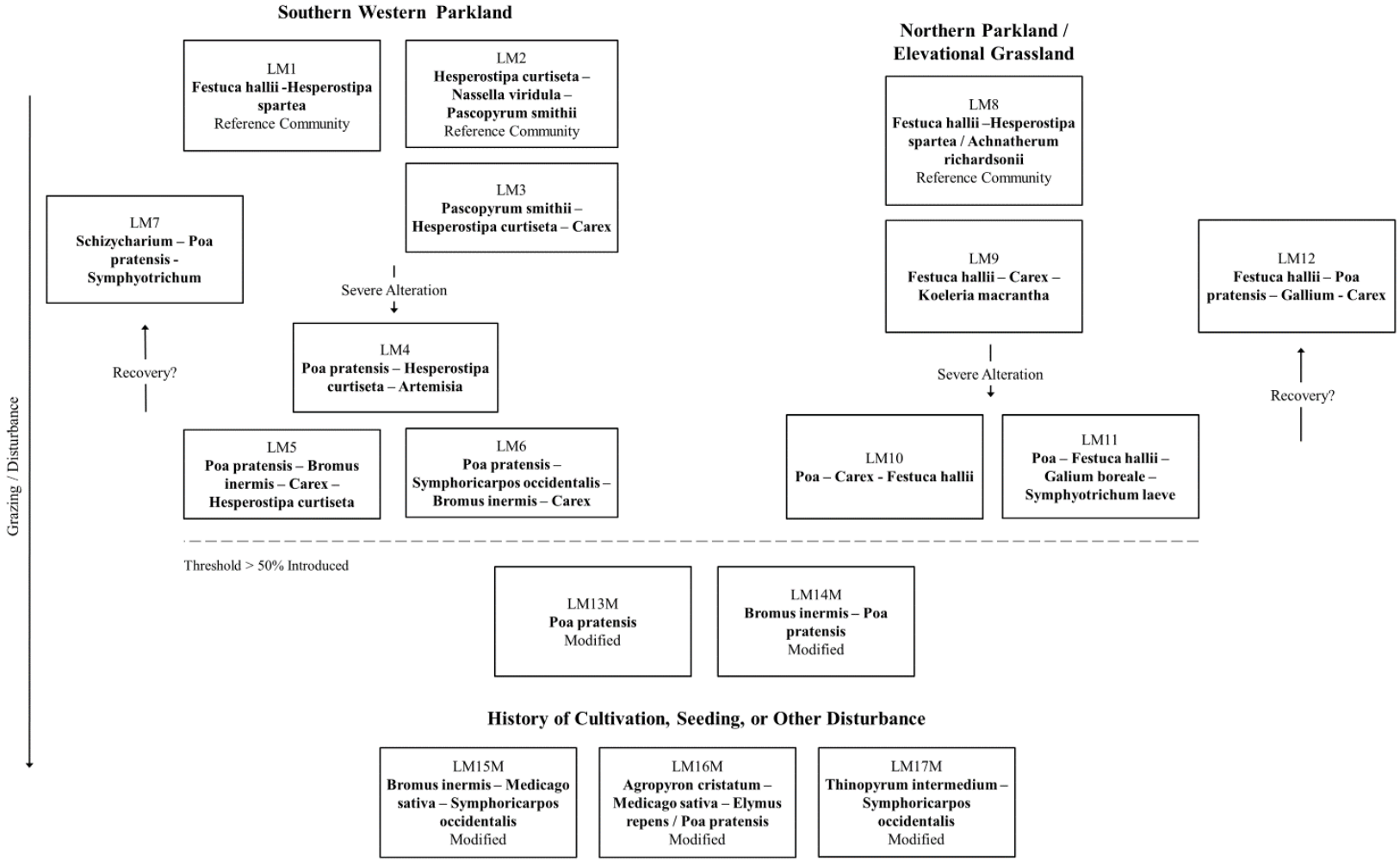
7. Plant Community Descriptions for the Aspen Parkland and Assiniboine Delta (APAD)

Image 2. Plant communities associated with diverse ecosites (Loam, Moist Loam, Eroded Slopes, Alluvium) along the Qu'Appelle Valley. In the foreground green needlegrass (*Nassella viridula*) is dominant.

Loam (LM) – APAD

State-and-Transition Diagram

Grassland



Description of Loam State and Transition Diagram

Loams in the southwest, at lower elevations, are drier and warmer (**LM1** to **LM6**). They can be dominated by plains rough fescue (*Festuca hallii*) and speargrasses (*Hesperostipa* spp.), but speargrasses are more abundant relative to fescue than in the northern and elevational areas of the ecoregion. With overgrazing they would likely degrade to a Kentucky bluegrass-sedge community, or one dominated by grazing tolerant and disturbance-induced natives, if minimal Kentucky bluegrass invasion occurs. The loams in the southeast (warm and moister) are under-represented and would likely consist of more warm season grasses such as big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), and prairie dropseed (*Sporobolus heterolepis*).

Data sources have provided us with a gradient of latitude and elevation for Aspen Parkland loams. Northern/elevational communities (**LM8** to **LM12**) tend to succeed towards a rough fescue (Festuca hallii) dominated community, often with speargrasses (*Hesperostipa* spp. and *Achnatherum richardsonii*). They are highly susceptible to Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and woody invasion. The fescue communities, if damaged and invaded by Kentucky bluegrass, may recover to various levels depending on how much regression occurred, but Kentucky bluegrass persists.

Loam in Manitoba typically consists of black chernozems making this a favourable soil for cultivation. Many of communities sampled for this analysis were influenced by historical disturbances that attempted to clear brush for annual crops and eventually were abandoned or converted into pasture, recovery from these disturbances is likely expressed in the composition in communities with trace amounts of native grasses and forb increasers. Communities dominated by alfalfa and intermediate wheatgrass were likely seeded (e.g. **LM15M** to **LM17M**). It is hard to recognize seeded areas if a stand has not been maintained, and/or it was unsustainably grazed resulting in the increase of non-native bluegrass and smooth brome. Brush encroachment is evident in communities dominated by non-native grasses, which could indicate lack of long-term stand maintenance. Key domestic species, and suites of species are used to determine if a community may have been subjected once to seeding. Intermediate wheatgrass (*Thinopyrum intermedium*), crested wheatgrass (*Agropyron cristatum*), Canada bluegrass (*Poa compressa*), and alfalfa (*Medicago sativa*) are good indicators of seeding history as they are less likely to be invasive in Manitoba's growing environment. Smooth brome (*Bromus inermis*) can be invasive, but if found with other domestic species (especially alfalfa), it is a good chance that the stand was seeded at one time. Over time, seeded stands may degrade to Kentucky bluegrass and weedy forbs, and sometimes enough natives will be present to suggest a possibility of succeeding to a mixture of native and tame species. Full recovery is unlikely where smooth brome or Kentucky bluegrass are concerned, but improved grazing practices can drive a stand towards its more productive tame species. Productive stands can still provide a significant level of ecological goods and services.

LM1 – APAD

Festuca hallii – Hesperostipa spartea / Hesperostipa curtiseta

Plains Rough Fescue – Porcupine-grass / Western Porcupine-grass

Loam

(n=5) Despite having abundant Kentucky bluegrass, this community reflects what we would expect for a **reference plant community** on Loam in many parts of the ecoregion. Plains rough fescue and porcupine-grass are the most abundant species. Native increasers are present but make up a small portion. Data available for this community description shows the sensitivity of the loam ecosite to invasion by exotic grasses. This reference plant community is provisional and subject to change with future data collection.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=5)	% Relative (n=5)
Major Graminoids (73.0%)			
Plains rough fescue (*Festuca hallii*)		12.1	16.3
Porcupine-grass (*Hesperostipa spartea*)		10.1	13.6
Kentucky bluegrass (*Poa pratensis*)		10	13.6
Western porcupine-grass (*Hesperostipa curtiseta*)		5.5	7.4
Grassland sedge (*Carex* spp.)		5.3	7.2
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		4.5	6.1
Smooth brome (*Bromus inermis*)		1.8	2.4
Sand dropseed (*Sporobolus cryptandrus*)		1.4	1.9
Western wheatgrass (*Pascopyrum smithii*)		1.1	1.5
Green needlegrass (*Nassella viridula*)		0.9	1.2
Junegrass (*Koeleria macrantha*)		0.7	0.9
Northern wheatgrass (*Elymus lanceolatus*)		0.3	0.4
Needle and threadgrass (*Hesperostipa comata*)		0.2	0.3
Hooker's oatgrass (*Avenula hookeri*)		0.2	0.3
Blue grama (*Bouteloua gracilis*)		0.2	0.3
Plains muhly (*Muhlenbergia cuspidata*)		0.1	0.1
Mat muhly (*Muhlenbergia richarsonis*)		0.1	0.1
Major Forbs (24.0%)			
Undifferentiated forbs		5.4	7.3
Prairie sage (*Artemisia ludoviciana*)		3.8	5.1
Fringed sage (*Artemisia frigida*)		2.5	3.4
Northern bedstraw (*Galium boreale*)		1.8	2.4
Purple prairie clover (*Dalea purpurea*)		1.2	1.6
Canada thistle (*Cirsium arvense*)		1.1	1.5
Goldenrod (*Solidago* spp.)		1	1.4
Common yarrow (*Achillea millefolium*)		0.2	0.3
Major Shrubs (3.0%)			
Rose (*Rosa* spp.)		1	1.3
Western snowberry (*Symphoricarpos occidentalis*)		0.8	1.1
Wolf willow (*Elaeagnus commutata*)		0.2	0.3

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	81.2	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	11.8	
Litter (n=0)	-	Relative Exotic (%)	18.8	
Bare soil (n=0)	-	Exotic Richness	2	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=0)	-	Pielou's Evenness Index	0.86	

LM2 – APAD

Hesperostipa curtiseta – Nassella viridula – Pascopyrum smithii

Western Porcupine-grass – Green Needlegrass – Western Wheatgrass

Loam

(n=7) This potential **reference plant community** is expected to occur on more xeric loams that resemble Mixedgrass prairie due to dominance of western porcupine-grass and relatively higher representation of wheatgrasses. Plains rough fescue is absent within the dataset but could be present. Increasers and exotic invaders make up a small amount of the composition. Note this data was sourced from SE Saskatchewan and is most applicable to xeric prairies in SW Manitoba.

Species Composition	% Biomass (n=7)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (83.5%)			
Western porcupine-grass (*Hesperostipa curtiseta*)	15.8		
Green needlegrass (*Nassella viridula*)	14		
Western wheatgrass (*Pascopyrum smithii*)	12.9		
Junegrass (*Koeleria macrantha*)	11.7		
Grassland sedge (*Carex* spp.)	7.4		
Northern wheatgrass (*Elymus lanceolatus*)	7.4		
Exotic bluegrass (*Poa* spp.)	5.8		
Blue grama (*Bouteloua gracilis*)	3.6		
Needle and threadgrass (*Hesperostipa comata*)	2.4		
Russian wildrye (*Psathyrostachys juncea*)	1.4		
Saltgrass (*Distichlis spicata* var. *stricta*)	0.9		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	0.1		
Hooker's oatgrass (*Avenula hookeri*)	0.1		
Major Forbs (15.9%)			
Prairie crocus (*Pulsatilla patens*)	5.7		
Fringed sage (*Artemisia frigida*)	4.4		
Undifferentiated forbs	0.9		
Vetch (*Vicia* spp.)	0.8		
Prickly-pear cactus (*Opuntia* spp.)	0.8		
Goldenrod (*Solidago* spp.)	0.6		
Common yarrow (*Achillea millefolium*)	0.5		
Pygmy flower (*Androsace septentrionalis*)	0.4		
Phlox moss (*Phlox hoodii*)	0.4		
Pussy toes (*Antennaria* spp.)	0.3		
Showy milkweed (*Asclepias speciosa*)	0.3		
Scarlet mallow (*Sphaeralcea coccinea*)	0.3		
Cinquefoil (*Potentilla* spp.)	0.3		
Hairy golden aster (*Heterotheca villosa*)	0.2		
Silverweed cinquefoil (*Argentina anserina*)	0.1		
Major Shrubs (0.6%)			
Western snowberry (*Symphoricarpos occidentalis*)	0.6		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	92.8	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	14.3	
Litter (n=0)	-	Relative Exotic (%)	7.2	
Bare soil (n=0)	-	Exotic Richness	0.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

LM3 – APAD

Pascopyrum smithii – Hesperostipa curtiseta – Carex

Western wheatgrass – Western Porcupine-grass – Sedge

Loam

(n=9) This community is moderately altered from the **LM2** plant community, similarly this community is expected to occur on well drained soils in SW Manitoba. Western porcupine-grass has decreased and sedges, increaser forbs, and exotic bluegrasses have increased. Bare soil is high.

Species Composition	% Biomass (n=9)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (73.2%)			
Western wheatgrass (*Pascopyrum smithii*)	17.7		
Western porcupine-grass (*Hesperostipa curtiseta*)	12		
Grassland sedge (*Carex* spp.)	9.6		
Junegrass (*Koeleria macrantha*)	9.4		
Exotic bluegrass (*Poa* spp.)	7.3		
Green needlegrass (*Nassella viridula*)	7.1		
Needle and threadgrass (*Hesperostipa comata*)	3.3		
Blue grama (*Bouteloua gracilis*)	3.1		
Northern wheatgrass (*Elymus lanceolatus*)	3.1		
Plains muhly (*Muhlenbergia cuspidata*)	0.4		
Poverty oatgrass (*Danthonia spicata*)	0.1		
Major Forbs (25.6%)			
Prairie crocus (*Pulsatilla patens*)	7.7		
Fringed sage (*Artemisia frigida*)	5.6		
Common yarrow (*Achillea millefolium*)	2.7		
Goldenrod (*Solidago* spp.)	2.3		
Undifferentiated forbs	1.4		
Vetch (*Vicia* spp.)	1.2		
Pussy toes (*Antennaria* spp.)	0.8		
Showy milkweed (*Asclepias speciosa*)	0.7		
Prairie smoke (*Geum triflorum*)	0.5		
Dandelion (*Taraxacum officinale*)	0.4		
Prairie sage (*Artemisia ludoviciana*)	0.3		
Scarlet mallow (*Sphaeralcea coccinea*)	0.3		
Plains wormwood (*Artemisia campestris*)	0.3		
Hairy golden aster (*Heterotheca villosa*)	0.2		
Harebell (*Campanula rotundifolia*)	0.2		
Phlox moss (*Phlox hoodii*)	0.2		
Cinquefoil (*Potentilla* spp.)	0.1		
Major Shrubs (1.3%)			
Western snowberry (*Symphoricarpos occidentalis*)	1		
Rose (*Rosa* spp.)	0.3		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	40	Relative Native (%)	92.0	**Forage Production (kg/ha)**
Clubmoss (n=1)	12	Native Richness	15.1	
Litter (n=1)	18	Relative Exotic (%)	8.0	
Bare soil (n=1)	20	Exotic Richness	1.2	
Lichen (n=0)	-	Shannon's Diversity Index	2.4	
Moss (n=1)	0	Pielou's Evenness Index	0.85	

LM4 – APAD

Poa pratensis – Hesperostipa curtiseta – Artemisia

Kentucky Bluegrass –Western Porcupine-grass – Sages

Loam

(n=11) This significantly altered native grassland has high representation of Kentucky bluegrass and forb increasers like prairie sage and fringed sage which tend to increase with heavy grazing pressure. Decreaser plants are still present and diverse. Bare soil is high and herbaceous cover is likely low.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=10)	% Relative (n=11)
Major Graminoids (72.6%)			
Kentucky bluegrass (*Poa pratensis*)	37	25.5	34.2
Western porcupine-grass (*Hesperostipa curtiseta*)	6	6.8	8.9
Grassland sedge (*Carex* spp.)	15	4.4	7.0
Needle and threadgrass (*Hesperostipa comata*)	0	3.8	4.0
Smooth brome (*Bromus inermis*)	1.5	2.3	2.7
Green needlegrass (*Nassella viridula*)	0	1.9	2.5
Northern wheatgrass (*Elymus lanceolatus*)	6	1.3	2.4
Porcupine-grass (*Hesperostipa spartea*)	0	1.7	1.8
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1	1.5	1.7
Western wheatgrass (*Pascopyrum smithii*)	1.5	0.7	1
Plains rough fescue (*Festuca hallii*)	0	0.8	1
Blue grama (*Bouteloua gracilis*)	0	0.7	0.9
Crested wheatgrass (*Agropyron cristatum*)	0	0.8	0.8
Junegrass (*Koeleria macrantha*)	0	0.5	0.7
Mat muhly (*Muhlenbergia richarsonis*)	0	0.4	0.6
Sandgrass (*Calamovilfa longifolia*)	0	0.4	0.5
Plains muhly (*Muhlenbergia cuspidata*)	3	0.1	0.4
Saltgrass (*Distichlis spicata* var. *stricta*)	0.5	0.2	0.4
Hooker's oatgrass (*Avenula hookeri*)	0	0.2	0.2
Major Forbs (26.7%)			
Undifferentiated forbs	0	7.7	8.9
Prairie sage (*Artemisia ludoviciana*)	1	6.4	7.3
Fringed sage (*Artemisia frigida*)	2	3.5	4.2
Northern bedstraw (*Galium boreale*)	0	1.7	2.1
Goldenrod (*Solidago* spp.)	10.5	0.1	1.3
Dandelion (*Taraxacum officinale*)	0	0.4	0.7
Common yarrow (*Achillea millefolium*)	3.5	0.3	0.6
White sweet clover (*Melilotus alba*)	0	0.5	0.5
Vetch (*Vicia* spp.)	0	0.3	0.3
Perennial sowthistle (*Sonchus arvensis*)	0	0.3	0.3
Major Shrubs (0.7%)			
Western snowberry (*Symphoricarpos occidentalis*)	2.5	0.2	0.5
Rose (*Rosa* spp.)	0	0.1	0.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	35	Relative Native (%)	60.1	**Forage Production (kg/ha)**
Clubmoss (n=1)	1	Native Richness	11.5	
Litter (n=1)	36	Relative Exotic (%)	39.9	
Bare soil (n=1)	14	Exotic Richness	2.2	
Lichen (n=0)	-	Shannon's Diversity Index	2.0	
Moss (n=1)	0	Pielou's Evenness Index	0.79	

LM5 – APAD

Bromus inermis – Poa pratensis – Hesperostipa curtiseta

Smooth Brome – Kentucky Bluegrass – Western Porcupine-grass

Loam

(n=4) This significantly altered native grassland, altered further from **LM4** contains a greater representation of cool season invasive grasses Kentucky bluegrass and smooth brome which tend to increase with a history of intense disturbance.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=4)	% Relative (n=4)
Major Graminoids (68.2%)			
Smooth brome (*Bromus inermis*)		18.6	22.4
Kentucky bluegrass (*Poa pratensis*)		14.6	17.6
Western porcupine grass (*Hesperostipa curtiseta*)		6.1	7.4
Sandgrass (*Calamovilfa longifolia*)		5.2	6.3
Grassland sedge (*Carex* spp.)		3.3	3.9
Green needlegrass (*Nassella viridula*)		1.5	1.8
Hooker's oatgrass (*Avenula hookeri*)		1.3	1.5
Plains rough fescue (*Festuca hallii*)		1.1	1.4
Big bluestem (*Andropogon gerardii*)		1	1.2
Needle and threadgrass (*Hesperostipa comata*)		1	1.2
Northern wheatgrass (*Elymus lanceolatus*)		0.9	1.1
Blue grama (*Bouteloua gracilis*)		0.6	0.8
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.5	0.6
Sand dropseed (*Sporobolus cryptandrus*)		0.4	0.5
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		0.3	0.3
Western wheatgrass (*Pascopyrum smithii*)		0.1	0.2
Major Forbs (21.9%)			
Undifferentiated forbs		8.2	9.8
Northern bedstraw (*Galium boreale*)		4.1	5
Prairie sage (*Artemisia ludoviciana*)		2	2.4
Wild licorice (*Glycyrrhiza lepidota*)		1.1	1.4
Fringed sage (*Artemisia frigida*)		1.1	1.4
Common yarrow (*Achillea millefolium*)		0.4	0.5
Canada thistle (*Cirsium arvense*)		0.4	0.5
Buffalo bean (*Thermopsis rhombifolia*)		0.3	0.3
Goat's beard (*Tragopogon dubius*)		0.3	0.3
Silverleaf scurfpea (*Pediomelum argophyllum*)		0.3	0.3
Major Shrubs (9.9%)			
Western snowberry (*Symphoricarpos occidentalis*)		6	7.2
Wolf willow (*Elaeagnus commutata*)		1.8	2.1
Rose (*Rosa* spp.)		0.5	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	40.5	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	12.0	
Litter (n=0)	-	Relative Exotic (%)	59.5	
Bare soil (n=0)	-	Exotic Richness	2.5	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

LM6 – APAD

Poa pratensis – Symphoricarpos occidentalis – Bromus inermis – Carex

Kentucky Bluegrass – Western Snowberry – Smooth Brome – Sedge

Loam

(n=7) This severely altered native grassland, grass decreasers present in **LM5** like western porcupine-grass are reduced or eliminated and there is increased encroachment from western snowberry. Native decreasers occupy a very small proportion of the herbaceous composition and forb increasers, including non-native species, are relatively higher. Some of the native grasses present, and the abundance of shrubs could indicate a microsite with higher moisture like a slight depression or ephemeral drainage pathway.

Species Composition	% Biomass (n=4)	% Foliar Cover (n=3)	% Relative (n=7)
Major Graminoids (53.7%)			
Kentucky bluegrass (*Poa pratensis*)	21.8	57	23.9
Smooth brome (*Bromus inermis*)	15	21.4	13.8
Grassland sedge (*Carex* spp.)	3.8	21.3	5.9
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	3.1	1	2.3
Western wheatgrass (*Pascopyrum smithii*)	3.9	0	2.2
Sandberg's bluegrass (*Poa secunda* sbsp. *secunda*)	1.8	0	1
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	3.8	1.8
Oatgrass (*Danthonia* spp.)	1.3	0	0.7
Major Forbs (29.4%)			
Northern bedstraw (*Galium boreale*)	3.5	11	4.1
Strawberry (*Fragaria virginiana*)	5.5	0	3.1
Common yarrow (*Achillea millefolium*)	3.6	0.7	2.2
American vetch (*Vicia americana*)	2	5	1.9
Tall meadowrue (*Thalictrum dasycarpum*)	1	6.4	1.6
Prairie sage (*Artemisia ludoviciana*)	1.5	1.5	1.6
Canada anemone (*Anemone canadensis*)	1.1	5	1.5
Cream peavine (*Lathyrus ochroleucus*)	0	7	1.1
Goldenrod (*Solidago* spp.)	0.9	1	1
Aster (*Symphyotrichum* spp.)	1	2.3	1
Dandelion (*Taraxacum officinale*)	1.6	0	0.9
Buffalo bean (*Thermopsis rhombifolia*)	1.4	0	0.8
Pussy toes (*Antennaria* spp.)	1.3	0	0.7
Northern gentian (*Gentianella amarella*)	1.3	0	0.7
Meadowrue (*Thalictrum* spp.)	1.3	0	0.7
Perennial sowthistle (*Sonchus arvensis*)	1	0	0.6
Milkvetch (*Astragalus* spp.)	1	0	0.6
Star-flowered false Solomon's seal (*Maianthemum stellatum*)	0.4	2	0.5
Tall bluebells (*Mertensia paniculata*)	0.9	0	0.5
Major Shrubs (16.9%)			
Western snowberry (*Symphoricarpos occidentalis*)	7.1	40.8	14.9
Rose (*Rosa* spp.)	2.5	0.3	1.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=4)	72 (78-93)	Relative Native (%)	59.7	**Forage Production (kg/ha)**
Clubmoss (n=7)	1 (0-2)	Native Richness	17.4	
Litter (n=7)	37 (25-55)	Relative Exotic (%)	40.3	
Bare soil (n=7)	7 (0-24)	Exotic Richness	3.1	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=7)	0	Pielou's Evenness Index	0.74	

LM7 – APAD

Schizachyrium scoparium – Poa pratensis – Symphyotrichum laeve

Little Bluestem – Kentucky Bluegrass – Smooth Blue Aster

Loam

(n=7) This altered community is dominated by little bluestem followed by Kentucky bluegrass and smooth aster. This community is an outlier, with most of the data collected from an area with a history of continuous grazing and recovery after the implementation of rotational grazing. Thus, increases of little bluestem on Loam is likely initiated by a history of intense disturbance.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=6)	% Relative (n=7)
Major Graminoids (46.9%)			
Little bluestem (*Schizachyrium scoparium*)	20.5	9.4	28.6
Kentucky bluegrass (*Poa pratensis*)	8.3	4	11.9
Porcupine-grass (*Hesperostipa spartea*)	4.4	0.3	1.3
Poverty oatgrass (*Danthonia spicata*)	8.6	0	1.2
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	0.3	0.3	0.8
Smooth brome (*Bromus inermis*)	1.8	0.2	0.7
Grassland sedge (*Carex* spp.)	4.3	0	0.6
Quackgrass (*Elymus repens*)	0	0.2	0.6
Major Forbs (46.0%)			
Smooth blue aster (*Symphyotrichum laeve*)	0	3.7	10
Common alfalfa (*Medicago sativa*)	0	2.7	7
Native thistle (*Cirsium* spp.)	0	1.3	3.4
Strawberry (*Fragaria virginiana*)	0	1.2	3.2
Brown-eyed Susan (*Rudbeckia hirta*)	0	1.2	3.1
Velvety goldenrod (*Solidago mollis*)	0	1	2.6
Tufted white prairie aster (*Symphyotrichum ericoides*)	0	0.7	1.8
Long-fruited thimbleweed (*Anemone cylindrica*)	0	0.6	1.7
Pussy toes (*Antennaria* spp.)	7.1	0.1	1.2
Canada thistle (*Cirsium arvense*)	0	0.4	1.1
Goldenrod (*Solidago* spp.)	4.8	0.1	1.1
Northern bedstraw (*Galium boreale*)	4.5	0.1	1
Wild licorice (*Glycyrrhiza lepidota*)	0	0.4	1
Prairie smoke (*Geum triflorum*)	5.7	0	0.8
Groundsel (*Senecio/Packera* spp.)	5.5	0	0.8
Black medic (*Medicago lupulina*)	1	0.2	0.8
Missouri goldenrod (*Solidago missouriensis*)	0	0.2	0.6
Silverleaf scurfpea (*Pediomelum argophyllum*)	0	0.2	0.6
Bee balm (*Monarda fistulosa*)	2	0.1	0.6
Common yarrow (*Achillea millefolium*)	1.8	0.1	0.5
Major Shrubs (7.1%)			
Rose (*Rosa* spp.)	0	1.9	5.2
Western snowberry (*Symphoricarpos occidentalis*)	0	0.7	1.8

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	36 (27-60)	Relative Native (%)	87.9	**Forage Production (kg/ha)**
Clubmoss (n=1)	0	Native Richness	22	
Litter (n=7)	62 (33-68)	Relative Exotic (%)	22.1	
Bare soil (n=1)	8	Exotic Richness	5.1	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=1)	0	Pielou's Evenness Index	0.75	

LM8 – APAD

Festuca hallii – Hesperostipa spartea / Achnatherum richardsonii

Plains Rough Fescue – Porcupine-grass – Richardson's Needlegrass

Loam

(n=5) Despite having abundant Kentucky bluegrass and high amounts of forbs, this community shows what we would expect for a **reference plant community** representative of northern and elevational Aspen Parkland and grasslands of the boreal transition (e.g. Riding Mountain National Park). Plains rough fescue is dominant followed by porcupine-grass and Richardson's needlegrass. Forb cover is diverse, and shrub cover is relatively low. Bluegrass presence indicates the vulnerability of the community to modification by invasive exotic grasses.

Species Composition	% Biomass (n=)	% Foliar Cover (n=5)	% Relative (n=5)
Major Graminoids (66.5%)			
Plains rough fescue (*Festuca hallii*)		67.8	25.6
Porcupine-grass (*Hesperostipa spartea*)		22.4	8.5
Richardson's needlegrass (*Achnatherum richardsonii*)		21.2	8
Kentucky bluegrass (*Poa pratensis*)		14.6	5.5
Grassland sedge (*Carex* spp.)		14.4	5.4
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		11.2	4.2
Junegrass (*Koeleria macrantha*)		7.6	2.9
Hooker's oatgrass (*Avenula hookeri*)		5.8	2.2
Mat muhly (*Muhlenbergia richarsonis*)		3.2	1.2
Fringed brome (*Bromus ciliatus*)		1.6	0.6
Major Forbs (29.9%)			
Northern bedstraw (*Galium boreale*)		14.2	5.4
Prairie smoke (*Geum triflorum*)		7.6	2.9
Stiff goldenrod (*Solidago rigida*)		6.4	2.4
Smooth blue aster (*Symphyotrichum laeve*)		6.4	2.4
Canada goldenrod (*Solidago canadensis*)		4.6	1.7
Bee balm (*Monarda fistulosa*)		3.6	1.4
Ascending purple milkvetch (*Astragalus laxmannii* var. *robustior*)		3.6	1.4
Chickweed (*Cerastium arvense*)		3.4	1.3
American Vetch (*Vicia americana*)		3	1.1
Strawberry (*Fragaria virginiana*)		2.8	1.1
Missouri goldenrod (*Solidago missouriensis*)		2.6	1
Prairie sage (*Artemisia ludoviciana*)		2.2	0.8
Bastard toadflax (*Comandra umbellata*)		2.2	0.8
Tall meadowrue (*Thalictrum dasycarpum*)		1.8	0.7
Hoary puccoon (*Lithospermum canescens*)		1.6	0.6
Major Shrubs (3.6%)			
Prickly rose (*Rosa acicularis*)		5.8	2.2
Saskatoon (*Amelanchier alnifolia*)		1.8	0.7
Western snowberry (*Symphoricarpos occidentalis*)		1.6	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	94.7	**Forage Production (kg/ha)**
Clubmoss (n=5)	0	Native Richness	44.4	
Litter (n=5)	37 (20-51)	Relative Exotic (%)	5.3	
Bare soil (n=5)	5 (0-10)	Exotic Richness	1.6	
Lichen (n=0)	-	Shannon's Diversity Index	2.7	
Moss (n=5)	11 (0-43)	Pielou's Evenness Index	0.71	

LM9 – APAD

Festuca hallii – Carex – Koeleria macrantha

Plains Rough Fescue – Sedge – Junegrass

Loam

(n=13) A moderately altered community from **LM8** with slight reductions in plains rough fescue. Kentucky bluegrass remains low, but there is elevated graminoid increasers like sedges and Junegrass. Porcupine-grass and Richardson's needlegrass, key decreasers, are also reduced, allowing increaser grasses and forbs to become dominant.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=13)	% Relative (n=13)
Major Graminoids (62.2%)			
Plains rough fescue (*Festuca hallii*)		49.2	21.2
Grassland sedge (*Carex* spp.)		28.9	12.5
Junegrass (*Koeleria macrantha*)		12.9	5.5
Porcupine-grass (*Hesperostipa spartea*)		9.3	4.0
Richardson's needlegrass (*Achnatherum richardsonii*)		8.5	3.6
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		8.1	3.5
Kentucky bluegrass (*Poa pratensis*)		8.0	3.4
Fringed brome (*Bromus ciliatus*)		4.5	1.9
Tickle hairgrass (*Agrostis scabra*)		3.6	1.6
Little bluestem (*Schizachyrium scoparium*)		2.2	1.0
Intermediate oatgrass (*Danthonia intermedia*)		1.2	0.5
Major Forbs (34.5%)			
Smooth blue aster (*Symphyotrichum laeve*)		10.1	4.3
Strawberry (*Fragaria virginiana*)		8.3	3.6
Northern bedstraw (*Galium boreale*)		7.5	3.2
Prairie smoke (*Geum triflorum*)		7.5	3.2
Common yarrow (*Achillea millefolium*)		5.6	2.4
Stiff goldenrod (*Solidago rigida*)		4.8	2.1
Hoary puccoon (*Lithospermum canescens*)		3.9	1.7
American vetch (*Vicia americana*)		3.7	1.6
Smooth fleabane (*Erigeron glabellus*)		2.3	1.0
Blue-eyed grass (*Sisyrinchium montanum*)		2.2	0.9
Prairie sage (*Artemisia ludoviciana*)		2.0	0.9
Chickweed (*Cerastium arvense*)		1.6	0.7
Canada anemone (*Anemone canadensis*)		1.5	0.7
Bastard toadflax (*Comandra umbellata*)		1.5	0.6
Missouri goldenrod (*Solidago missouriensis*)		1.4	0.6
Cream peavine (*Lathyrus ochroleucus*)		1.3	0.6
Anise hyssop (*Agastache foeniculum*)		1.3	0.5
Major Shrubs (3.3%)			
Kinnikinnick (*Arctostaphylos uva-ursi*)		4.5	1.9
Shrubby cinquefoil (*Dasiphora fruticosa*)		1.9	0.8

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	96.0	**Forage Production (kg/ha)**
Clubmoss (n=13)	0	Native Richness	42.2	
Litter (n=11)	40 (29-51)	Relative Exotic (%)	4.0	
Bare soil (n=11)	5 (0-11)	Exotic Richness	1.5	
Lichen (n=0)	-	Shannon's Diversity Index	2.8	
Moss (n=11)	4 (0-32)	Pielou's Evenness Index	0.73	

LM10 – APAD

Exotic *Poa – Carex – Festuca hallii*

Exotic Bluegrass – Sedge – Plains Rough Fescue

Loam

(n=13) Significantly altered native fescue grassland where Kentucky blugrass and sedge increasers have displaced native decreaser grasses from the reference plant community as a result of historical grazing disturbance and exotic invasion.

Species Composition	% Biomass (n=2)	% Foliar Cover (n=11)	% Relative (n=13)
Major Graminoids (60.1%)			
Exotic bluegrass (*Poa* spp.)	15	56.1	21.3
Grassland sedge (*Carex* spp.)	12.3	21.2	9.3
Plains rough fescue (*Festuca hallii*)	0	19.1	6.2
Junegrass (*Koeleria macrantha*)	4.8	13.5	5.4
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	16.2	5.2
Porcupine-grass (*Hesperostipa spartea*)	0	13.5	4.3
Intermediate oatgrass (*Danthonia intermedia*)	0	4.8	1.7
Fringed brome (*Bromus ciliatus*)	0	3.8	1.3
Smooth brome (*Bromus inermis*)	8	0	1.2
Richardson's needlegrass (*Achnatherum richardsonii*)	0	3.5	1.1
Tickle hairgrass (*Agrostis scabra*)	0.8	1.9	0.8
Mat muhly (*Muhlenbergia richardsonis*)	0	1.6	0.6
Sweetgrass (*Anthoxanthum hirtum*)	0	1.3	0.5
Major Forbs (37.0%)			
Northern bedstraw (*Galium boreale*)	4.5	8.4	3.7
American vetch (*Vicia americana*)	2.5	9.5	3.7
Common yarrow (*Achillea millefolium*)	6.3	6.3	3.2
Dandelion (*Taraxacum officinale*)	5.3	6.2	3
Prairie sage (*Artemisia ludoviciana*)	4.5	4.4	2.3
Smooth fleabane (*Erigeron glabellus*)	0	4.4	1.9
Stiff goldenrod (*Solidago rigida*)	0	5.5	1.9
Smooth blue aster (*Symphyotrichum laeve*)	0	5.7	1.7
Strawberry (*Fragaria virginiana*)	2.3	3.9	1.7
Tall meadowrue (*Thalictrum dasycarpum*)	0	4.8	1.5
Canada goldenrod (*Solidago canadensis*)	5.3	0.3	0.9
Silverweed cinquefoil (*Argentina anserina*)	2.8	1.2	0.9
Ascending purple milkvetch (*Astragalus laxmannii* var. *robustior*)	0	2	0.7
Pussy toes (*Antennaria* spp.)	2.5	0.5	0.7
Missouri goldenrod (*Solidago missouriensis*)	0	1.8	0.6
Major Shrubs (2.9%)			
Western snowberry (*Symphoricarpos occidentalis*)	4	1.1	1
Shrubby cinquefoil (*Dasiphora fruticosa*)	0	1.8	0.6
Prickly rose (*Rosa acicularis*)	0	1.6	0.5

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=2)	67 (75-60)	Relative Native (%)	74.1	**Forage Production (kg/ha)**
Clubmoss (n=13)	0 (0-2)	Native Richness	38.3	
Litter (n=13)	38 (7-59)	Relative Exotic (%)	25.9	
Bare soil (n=13)	4 (0-11)	Exotic Richness	2.2	
Lichen (n=0)	-	Shannon's Diversity Index	2.8	
Moss (n=12)	0	Pielou's Evenness Index	0.76	

LM11 – APAD

Poa pratensis – Festuca hallii – Galium boreale / Symphyotrichum laeve

Kentucky Bluegrass – Plains Rough Fescue – Northern Bedstraw / Smooth Blue Aster

Loam

(n=13) This significantly altered community is dominated by Kentucky bluegrass; relatively high plains rough fescue is retained. Cover of forb increasers like northern bedstraw, smooth blue aster, and prairie sage have high foliar cover ≥ 10%. Compared to states **LM8** to **LM10** there are declines in overall richness. This community could represent bluegrass invasion, coupled with recovery from disturbance.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=13)	% Relative (n=13)
Major Graminoids (57.0%)			
Kentucky bluegrass (*Poa pratensis*)		73.5	25.4
Plains rough fescue (*Festuca hallii*)		41	14.2
Grassland sedge (*Carex* spp.)		13.3	4.6
Richardson's needlegrass (*Achnatherum richardsonii*)		7.7	2.7
Fringed brome (*Bromus ciliatus*)		5.6	1.9
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		5.4	1.9
Little bluestem (*Schizachyrium scoparium*)		3.3	1.1
Smooth brome (*Bromus inermis*)		2.5	0.8
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		2.3	0.8
Porcupine-grass (*Hesperostipa spartea*)		2.2	0.8
Marsh muhly (*Muhlenbergia racemosa*)		1.9	0.7
Major Forbs (38.5%)			
Northern bedstraw (*Galium boreale*)		16.4	5.7
Smooth blue aster (*Symphyotrichum laeve*)		14.8	5.1
Prairie sage (*Artemisia ludoviciana*)		10	3.5
Strawberry (*Fragaria virginiana*)		8.5	2.9
American vetch (*Vicia americana*)		7.2	2.5
Veiny meadowrue (*Thalictrum venulosum*)		6.1	2.1
Common yarrow (*Achillea millefolium*)		5	1.7
Hoary puccoon (*Lithospermum canescens*)		4.4	1.5
Bee balm (*Monarda fistulosa*)		4.2	1.4
Cream peavine (*Lathyrus ochroleucus*)		4	1.4
Stiff goldenrod (*Solidago rigida*)		3.2	1.1
American hedysarum (*Hedysarum alpinum*)		3.1	1.1
Canada anemone (*Anemone canadensis*)		2.9	1
Tarragon (*Artemisia dracunculus*)		2.7	0.9
Prairie smoke (*Geum triflorum*)		2.6	0.9
Anise hyssop (*Agastache foeniculum*)		2.1	0.7
Ascending purple milkvetch (*Astragalus laxmannii* var. *robustior*)		2.1	0.7
Major Shrubs (4.5%)			
Prickly rose (*Rosa acicularis*)		5.2	1.8
Western snowberry (*Symphoricarpos occidentalis*)		4.7	1.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	73.1	**Forage Production (kg/ha)**
Clubmoss (n=13)	0	Native Richness	32.5	
Litter (n=8)	51 (29-66)	Relative Exotic (%)	26.9	
Bare soil (n=8)	4 (0-9)	Exotic Richness	1.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.6	
Moss (n=8)	9 (0-53)	Pielou's Evenness Index	0.75	

LM12 – APAD

Festuca hallii – Poa pratensis – Galium boreale – Carex

Plains Rough Fescue – Kentucky Bluegrass – Northern Bedstraw – Sedge

Loam

(n=5) An altered community with high plains rough fescue cover followed by high Kentucky blugrass cover. Overall relative native cover is 85% and exotic richness is low. Increaser forbs remain high but increaser grasses are very low. This likely represents recovery from a history of disturbance and exotic invasion.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=5)	% Relative (n=5)
Major Graminoids (60.1%)			
Plains rough fescue (*Festuca hallii*)		68.6	23
Kentucky bluegrass (*Poa pratensis*)		43	14.4
Grassland sedge (*Carex* spp.)		17.2	5.8
Richardson's needlegrass (*Achnatherum richardsonii*)		15.4	5.2
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		7.6	2.5
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		6.8	2.3
Porcupine-grass (*Hesperostipa spartea*)		5.2	1.7
Little bluestem (*Schizachyrium scoparium*)		4.6	1.5
Fringed brome (*Bromus ciliatus*)		2	0.7
Junegrass (*Koeleria macrantha*)		1.6	0.5
Marsh muhly (*Muhlenbergia racemosa*)		1.4	0.5
Major Forbs (34.3%)			
Northern bedstraw (*Galium boreale*)		23.2	7.8
Strawberry (*Fragaria virginiana*)		9.4	3.1
Smooth blue aster (*Symphyotrichum laeve*)		8.8	3
Bee balm (*Monarda fistulosa*)		8.2	2.7
Cream peavine (*Lathyrus ochroleucus*)		6.8	2.3
Prairie smoke (*Geum triflorum*)		6	2
American vetch (*Vicia americana*)		5.8	1.9
Common yarrow (*Achillea millefolium*)		5.2	1.7
Anise hyssop (*Agastache foeniculum*)		3.4	1.1
Prairie sage (*Artemisia ludoviciana*)		3	1
Hoary puccoon (*Lithospermum canescens*)		3	1
Veiny meadowrue (*Thalictrum venulosum*)		2.8	0.9
Tarragon (*Artemisia dracunculus*)		2.6	0.9
Stiff goldenrod (*Solidago rigida*)		2.4	0.8
Smooth fleabane (*Erigeron glabellus*)		1.6	0.5
Major Shrubs (5.6%)			
Prickly rose (*Rosa acicularis*)		7	2.3
Saskatoon (*Amelanchier alnifolia*)		3.8	1.3
Shrubby cinquefoil (*Dasiphora fruticosa*)		2.4	0.8
Western snowberry (*Symphoricarpos occidentalis*)		2.2	0.7

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	85.1	**Forage Production (kg/ha)**
Clubmoss (n=5)	0	Native Richness	34.0	
Litter (n=2)	53 (45-60)	Relative Exotic (%)	14.9	
Bare soil (n=2)	2	Exotic Richness	1.2	
Lichen (n=0)	-	Shannon's Diversity Index	2.7	
Moss (n=2)	3 (1-4)	Pielou's Evenness Index	0.77	

LM13M (Modified) – APAD

Poa pratensis

Kentucky Bluegrass

Loam

(n=42) This **Modified** community represents severely altered native grasslands with significant increases in Kentucky bluegrass, which likely resulted from intense disturbances like heavy grazing or possible attempts to seed forages. Dominant bluegrass is accompanied by low-statured grazing tolerant forbs. Native grasses persist with low cover. Low native decreaser abundance makes it unlikely that this will return to a healthy native plant community without significant intervention. Productivity potential is high.

Species Composition	% Biomass (n=20)	% Foliar Cover (n=22)	% Relative (n=42)
Major Graminoids (72.2%)			
Kentucky bluegrass (*Poa pratensis*)	48.2	60.6	51
Grassland sedge (*Carex* spp.)	5	2.7	3.8
Smooth brome (*Bromus inermis*)	5	2.9	3.6
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.8	1.8	2.2
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	1.4	1.9	1.4
Cheatgrass (*Bromus tectorum*)	0	2.3	1.1
Western porcupine-grass (*Hesperostipa curtiseta*)	0	1.8	1.1
Quackgrass (*Elymus repens*)	0.2	1.2	0.7
Intermediate wheatgrass (*Thinopyrum intermedium*)	0	1.8	0.9
Little bluestem (*Schizachyrium scoparium*)	1.2	0	0.6
Western wheatgrass (*Pascopyrum smithii*)	0.4	0.4	0.5
Hairy wildrye (*Leymus innovatus*)	0.9	0	0.4
Plains rough fescue (*Festuca hallii*)	0	0.8	0.4
Major Forbs (21.8%)			
White clover (*Trifolium repens*)	6.7	0.1	3.2
Dandelion (*Taraxacum officinale*)	3.8	1.4	2.4
Strawberry (*Fragaria virginiana*)	4.1	0	2
Common yarrow (*Achillea millefolium*)	2.2	0.6	1.3
Northern bedstraw (*Galium boreale*)	1	1.7	1.1
Canada thistle (*Cirsium arvense*)	0.4	1.3	0.8
Common alfalfa (*Medicago sativa*)	0	1.5	0.7
Fringed sage (*Artemisia frigida*)	0.1	1.2	0.6
Goldenrod (*Solidago* spp.)	0.6	0.7	0.6
Pussy toes (*Antennaria* spp.)	1.2	0	0.5
Fleabane (*Erigeron* spp.)	1.1	0	0.5
White sweetclover (*Melilotus alba*)	0	1	0.5
Prairie sage (*Artemisia ludoviciana*)	0	1.1	0.5
Violet (*Viola* spp.)	0.9	0	0.4
Tufted white prairie aster (*Symphyotrichum ericoides*)	0	0.8	0.4
Major Shrubs (6.0%)			
Western snowberry (*Symphoricarpos occidentalis*)	0.6	11	4.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=19)	67 (50-82)	Relative Native (%)	32.6	**Forage Production (kg/ha)**
Clubmoss (n=22)	3 (0-38)	Native Richness	10.6	2912 kg/ha
Litter (n=23)	69 (34-89)	Relative Exotic (%)	67.4	
Bare soil (n=23)	6 (0-24)	Exotic Richness	4	
Lichen (n=0)	-	Shannon's Diversity Index	1.6	
Moss (n=23)	0.3 (0-8)	Pielou's Evenness Index	0.63	

LM14M (Modified) – APAD

Bromus inermis – Poa pratensis

Smooth Brome – Kentucky Bluegrass

Loam

(n=41) This **Modified** community is dominated by smooth brome and Kentucky bluegrass, likely originating from disturbances favouring their invasion or intentional seeding. Native grasses and forbs are considerably reduced. It is unlikely that this will return to a healthy native plant community without significant intervention. Herbaceous cover is high and soil exposure is low.

Species Composition	% Biomass (n=5)	% Foliar Cover (n=36)	% Relative (n=41)
Major Graminoids (76.0%)			
Smooth brome (*Bromus inermis*)	26.3	41.3	43.7
Exotic bluegrass (*Poa* spp.)	27.1	22.2	23.7
Grassland sedge (*Carex* spp.)	2.3	1.8	1.6
Needle and threadgrass (*Hesperostipa comata*)	0	1.2	1.2
Western porcupine-grass (*Hesperostipa curtiseta*)	0	0.8	0.9
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	0.7	0.6
Crested wheatgrass (*Agropyron cristatum*)	0	0.4	0.6
Green needlegrass (*Nassella viridula*)	0	0.5	0.6
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.6	0.2	0.5
Western wheatgrass (*Pascopyrum smithii*)	0.1	0.3	0.3
Plains rough fescue (*Festuca hallii*)	0	0.3	0.3
Quackgrass (*Elymus repens*)	0.2	0.3	0.3
Tickle hairgrass (*Agrostis scabra*)	1.7	0	0.2
Junegrass (*Koeleria macrantha*)	0.1	0.2	0.2
Major Forbs (18.5%)			
Undifferentiated forbs	0	6.1	6.3
Prairie sage (*Artemisia ludoviciana*)	0.2	1.7	2
Common alfalfa (*Medicago sativa*)	0	1.9	1.6
Fringed sage (*Artemisia frigida*)	0.4	1.4	1.4
Goldenrod (*Solidago* spp.)	5.3	0.2	0.9
Northern bedstraw (*Galium boreale*)	0	0.7	0.7
Common yarrow (*Achillea millefolium*)	3.3	0.2	0.6
Strawberry (*Fragaria virginiana*)	3.4	0.2	0.6
Canada thistle (*Cirsium arvense*)	0.3	0.4	0.5
Milkvetch (*Astragalus* spp.)	3.7	0	0.4
Dandelion (*Taraxacum officinale*)	2.4	0.1	0.4
American vetch (*Vicia americana*)	2.7	0	0.3
Stiff goldenrod (*Solidago rigida*)	0	0.7	0.2
White sweetclover (*Melilotus alba*)	0.7	0.2	0.2
Major Shrubs (5.5%)			
Western snowberry (*Symphoricarpos occidentalis*)	0.9	5.1	4.5
Rose (*Rosa* spp.)	1.6	0.6	0.8

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=5)	73 (58-82)	Relative Native (%)	18.5	**Forage Production (kg/ha)**
Clubmoss (n=6)	1 (0-5)	Native Richness	7.9	
Litter (n=6)	42 (29-66)	Relative Exotic (%)	71.5	
Bare soil (n=9)	6 (0-17)	Exotic Richness	3.1	
Lichen (n=3)	2 (0-5)	Shannon's Diversity Index	1.5	
Moss (n=6)	7 (0-41)	Pielou's Evenness Index	0.66	

LM15M (Modified) – APAD

Bromus inermis – Medicago sativa – Symphoricarpos occidentalis

Smooth Brome – Alfalfa – Western Snowberry

Loam

(n=25) This **Modified** grassland community represents sites that were likely seeded at one time with mixtures containing smooth brome and alfalfa. Light alteration has left it dominated by smooth brome and alfalfa, with low amounts of disturbance-induced species. Encroachment of native shrubs contributes the most native cover, native grasses and forbs have established in small amounts.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=25)	% Relative (n=25)
Major Graminoids (56.3%)			
Smooth brome (*Bromus inermis*)		58.4	48.4
Exotic bluegrass (*Poa* spp.)		5.2	4.3
Crested wheatgrass (*Agropyron cristatum*)		1.2	1
Needle and threadgrass (*Hesperostipa comata*)		0.8	0.7
Quackgrass (*Elymus repens*)		0.7	0.6
Intermediate wheatgrass (*Thinopyrum intermedium*)		0.6	0.5
Porcupine-grass (*Hesperostipa spartea*)		0.4	0.3
Grassland sedge (*Carex* spp.)		0.3	0.2
Green needlegrass (*Nassella viridula*)		0.3	0.2
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		0.1	0.1
Major Forbs (23.7%)			
Common alfalfa (*Medicago sativa*)		24.8	20.6
Undifferentiated forbs		1.2	1
Fringed sage (*Artemisia frigida*)		0.8	0.6
Wild licorice (*Glycyrrhiza lepidota*)		0.5	0.4
Northern bedstraw (*Galium boreale*)		0.3	0.3
Meadowrue (*Thalictrum* spp.)		0.2	0.2
White sweet clover (*Melilotus alba*)		0.2	0.1
Canada thistle (*Cirsium arvense*)		0.1	0.1
Vetch (*Vicia* spp.)		0.1	0.1
Prairie sage (*Artemisia ludoviciana*)		0.1	0.1
Major Shrubs (20.0%)			
Western snowberry (*Symphoricarpos occidentalis*)		17	14.1
Wolf willow (*Elaeagnus commutata*)		3.7	3.1
Rose (*Rosa* spp.)		2.1	1.7
Chokecherry (*Prunus virginiana*)		0.8	0.6
Poplar (*Populus* spp.)		0.3	0.2
Willow (*Salix* spp.)		0.2	0.2
Prickly rose (*Rosa acicularis*)		0.1	0.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	22.7	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	3.3	
Litter (n=0)	-	Relative Exotic (%)	77.3	
Bare soil (n=16)	3 (0-12)	Exotic Richness	3.1	
Lichen (n=16)	1 (0-15)	Shannon's Diversity Index	1.3	
Moss (n=0)	-	Pielou's Evenness Index	0.70	

LM16M (Modified) – APAD

Agropyron cristatum – Medicago sativa – Elymus repens /* Exotic *Poa

Crested Wheatgrass – Alfalfa – Quackgrass / Exotic Bluegrass

Loam

(n=25) This community represents sites that were seeded at one time with mixtures containing crested wheatgrass and alfalfa, and various other domestic grasses and legumes. This **Modified** grassland community is moderately altered as a result of aging of the stand without agronomic inputs or renovation, but very little invasion by undesirable plants. Native grasses and forbs provide low amounts of cover, but shrubs contribute the most native plant cover.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=25)	% Relative (n=25)
Major Graminoids (56.9%)			
Crested wheatgrass (*Agropyron cristatum*)		30.3	27.5
Quackgrass (*Elymus repens*)		9.9	9
Exotic bluegrass (*Poa* spp.)		9.3	8.5
Smooth brome (*Bromus inermis*)		5.5	5
Intermediate wheatgrass (*Thinopyrum intermedium*)		4.7	4.3
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		1.2	1.1
Baltic rush (*Juncus balticus*)		0.5	0.5
Green needlegrass (*Nassella viridula*)		0.4	0.3
Needle and threadgrass (*Hesperostipa comata*)		0.3	0.3
Western porcupine-grass (*Hesperostipa curtiseta*)		0.3	0.3
Foxtail barley (*Hordeum jubatum*)		0.2	0.1
Major Forbs (31.6%)			
Common alfalfa (*Medicago sativa*)		23.4	21.3
Undifferentiated forbs		2.4	2.2
Yellow sweet clover (*Melilotus officinalis*)		2.1	1.9
Fringed sage (*Artemisia frigida*)		1.8	1.7
Water smartweed (*Persicaria amphibia*)		0.9	0.8
Absinthe (*Artemisia absinthium*)		0.8	0.7
White sweet clover (*Melilotus alba*)		0.8	0.7
Cinquefoil (*Potentilla* spp.)		0.6	0.5
Goldenrod (*Solidago* spp.)		0.3	0.2
Strawberry (*Fragaria virginiana*)		0.2	0.2
Kochia (*Kochia scoparia*)		0.2	0.2
Canada thistle (*Cirsium arvense*)		0.2	0.2
Common yarrow (*Achillea millefolium*)		0.2	0.2
Major Shrubs (11.5%)			
Western snowberry (*Symphoricarpos occidentalis*)		8.3	7.5
Wolf willow (*Elaeagnus commutata*)		3	2.7
Prickly rose (*Rosa acicularis*)		0.6	0.5
Rose (*Rosa* spp.)		0.5	0.5
Poplar (*Populus* spp.)		0.3	0.3

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	19.9	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	4	
Litter (n=0)	-	Relative Exotic (%)	80.1	
Bare soil (n=8)	9 (0-20)	Exotic Richness	4.2	
Lichen (n=8)	0.4 (0-3)	Shannon's Diversity Index	1.4	
Moss (n=0)	-	Pielou's Evenness Index	0.71	

LM17M (Modified) – APAD

Thinopyrum intermedium – Symphoricarpos occidentalis

Intermediate Wheatgrass – Western Snowberry

Loam

(n=29) This **Modified** community represents sites that were likely seeded at one time with mixtures containing intermediate or tall wheatgrass and various legumes. Moderate alteration has left it still dominated by intermediate wheatgrass; native cover is contributed primarily by shrubs like western snowberry. Native grasses contribute ~5% cover while native forbs are nearly absent. Very low native decreaser cover suggests that it is unlikely that this will return to a healthy native plant community without significant intervention.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=29)	% Relative (n=29)
Major Graminoids (69.8%)			
Intermediate wheatgrass (*Thinopyrum intermedium*)		62.1	52.3
Tall wheatgrass (*Thinopyrum ponticum*)		6.5	5.5
Smooth brome (*Bromus inermis*)		5.8	4.9
Quackgrass (*Elymus repens*)		4.4	3.7
Foxtail barley (*Hordeum jubatum*)		1.5	1.2
Green needlegrass (*Nassella viridula*)		1.4	1.2
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		0.8	0.6
Tickle hairgrass (*Agrostis scabra*)		0.4	0.3
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.2	0.1
Major Forbs (14.3%)			
Common alfalfa (*Medicago sativa*)		2.6	2.2
Dandelion (*Taraxacum officinale*)		2.6	2.2
Yellow sweet clover (*Melilotus officinalis*)		2.6	2.2
Canada thistle (*Cirsium arvense*)		2.3	1.9
Undifferentiated forbs		1.9	1.6
White sweet clover (*Melilotus alba*)		1.6	1.3
Water smartweed (*Persicaria amphibia*)		0.7	0.6
Canada fleabane (*Conyza canadensis*)		0.6	0.5
Night-flowering catchfly (*Silene noctiflora*)		0.5	0.4
Black medic (*Medicago lupulina*)		0.4	0.3
Perennial sowthistle (*Sonchus arvensis*)		0.3	0.2
Flixweed (*Descurainia sophia*)		0.1	0.1
Major Shrubs (15.9%)			
Western snowberry (*Symphoricarpos occidentalis*)		12.5	10.5
Wolf willow (*Elaeagnus commutata*)		3.7	3.1
Rose (*Rosa* spp.)		1.2	1
Prickly rose (*Rosa acicularis*)		0.7	0.6
Wood rose (*Rosa woodsii*)		0.4	0.4
Trembling aspen (*Populus tremuloides*)		0.2	0.2
Saskatoon (*Amelanchier alnifolia*)		0.1	0.1

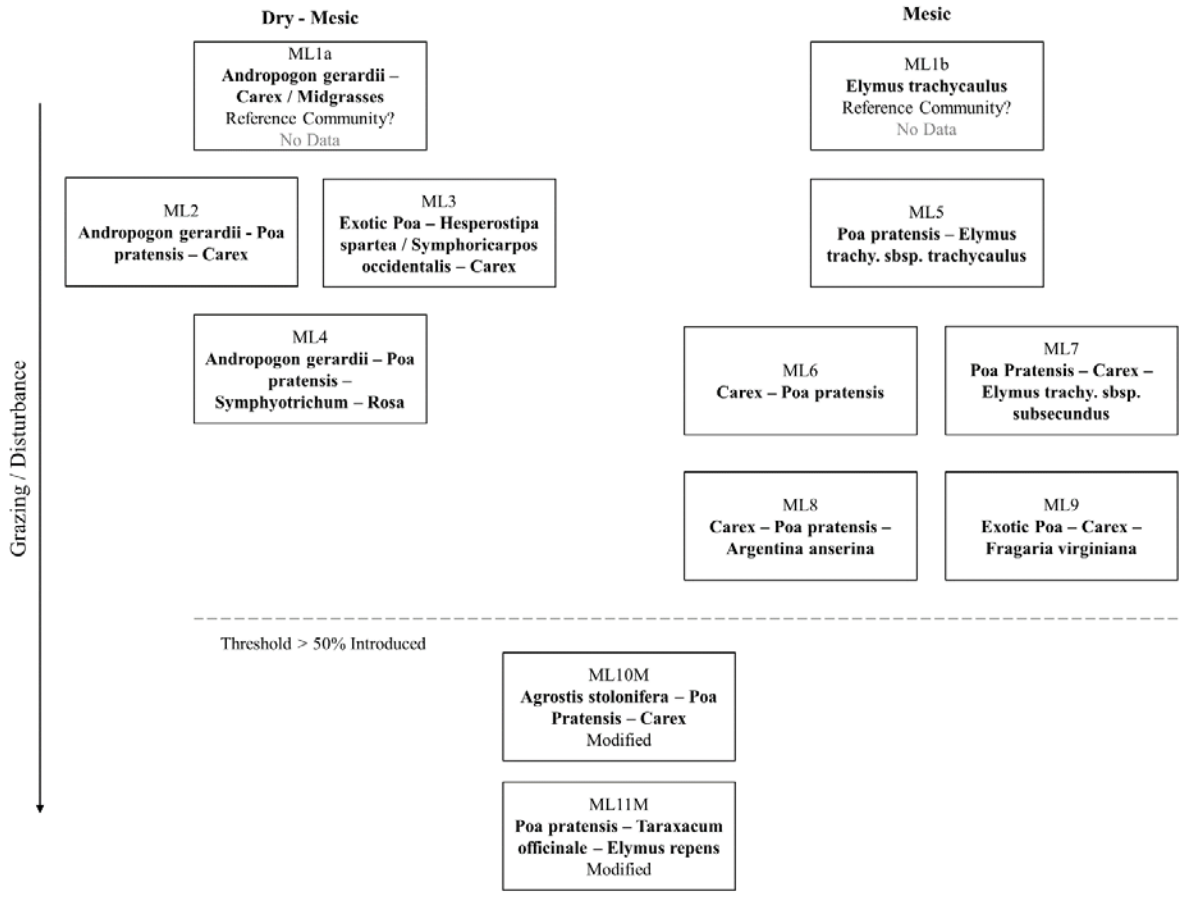
Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	21.1	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	3.6	
Litter (n=0)	-	Relative Exotic (%)	78.9	
Bare soil (n=12)	10 (0-30)	Exotic Richness	4.4	
Lichen (n=12)	0.3 (0-2)	Shannon's Diversity Index	1.3	
Moss (n=0)	-	Pielou's Evenness Index	0.63	

Moist Loam (ML) – APAD

State-and-Transition Diagram

Grassland

Potential reference plant community was not identified.



Description of Moist Loam S&T

There is a spectrum of moisture inherent among ecosites classified as Moist Loam because the classification requirement is water table existing temporarily anywhere between 0 and 50 cm of the soil surface. Communities that are wetter (**ML5 to ML9**) seem to have less big bluestem or other upland grasses, and more moisture-loving grasses and forbs. As a moist, fine-textured ecosite, there is risk of soil compaction resulting from disturbance. Bluegrass and bentgrass are the non-native species most likely to increase with inappropriate grazing disturbance, with bentgrass more likely to invade wetter sites. Further disturbance of altered or modified communities can result in increases disturbance tolerant forbs like silverweed cinquefoil (**ML8**), strawberry (**ML9**), and even dandelion (**ML11M**). Some brush encroachment is possible (**ML3**).

ML1a – APAD

***Andropogon gerardii – Carex /* Midgrasses**

Big Bluestem – Sedge / Midgrasses

Moist Loam

NO DATA

(n=0) The later seral reference plant community established on moist loams that are relatively dry-mesic would likely be dominated by big bluestem (*Andropogon gerardii*) accompanied by slender or awned wheatgrass (*Elymus trachycaulus* sbsp.), and sedge (*Carex* spp.) decreasers. Other indicators of moist loams could include mat muhly (*Muhlenbergia richardsonis*), tickle hairgrass (*Agrostis scabra*), or tufted hairgrass (*Deschampsia cespitosa*).

ML1b – APAD

Elymus trachycaulus

Slender / Awned Wheatgrass

Moist Loam

NO DATA

(n=0) Communities like **ML5** and **ML7** indicate that a later seral plant community indicative of relatively more mesic sites dominated by slender or awned wheatgrass (*Elymus trachycaulus* sbsp.) exists. This community would be associated with sedge decreasers and grassland forbs indicative of moisture.

ML2 – APAD

Andropogon gerardii – Poa pratensis – Carex

Big Bluestem – Kentucky Bluegrass – Sedge

Moist Loam

(n=8) An altered moist loam community retaining dominance of big bluestem which is likely a dominant grass in the potential reference plant community (**ML1a**). Disturbance and high soil moisture result in the emergence of non-native species and Kentucky bluegrass invasion. Similar dominant species are present in **ML4** but has divergent species composition, likely driven by forb abundance and diversity.

Species Composition	% Biomass (n=8)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (78.8%)			
Big bluestem (*Andropogon gerardii*)	32.7		
Kentucky bluegrass (*Poa pratensis*)	18		
Sedge (*Carex* spp.)	13.5		
Creeping bentgrass (*Agrostis stolonifera*)	3.6		
Little bluestem (*Schizachyrium scoparium*)	2.3		
Switchgrass (*Panicum virgatum*)	2.1		
Western porcupine-grass (*Hesperostipa curtiseta*)	1.6		
Prairie chordgrass (*Spartina pectinata*)	0.9		
Western wheatgrass (*Pascopyrum smithii*)	0.8		
Foxtail barley (*Hordeum jubatum*)	0.5		
Hooker's oatgrass (*Avenula hookeri*)	0.5		
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0.4		
Rush (*Juncus* spp.)	0.3		
Major Forbs (15.8%)			
Goldenrod (*Solidago* spp.)	2.4		
Aster (*Symphyotrichum* spp.)	2.1		
Dandelion (*Taraxacum officinale*)	1.5		
Pussy toes (*Antennaria* spp.)	1.2		
Undifferentiated forbs	0.8		
Common yarrow (*Achillea millefolium*)	0.7		
Northern bedstraw (*Galium boreale*)	0.7		
Silverweed cinquefoil (*Argentina ansernia*)	0.6		
Canada anemone (*Anemone canadensis*)	0.5		
Clover (*Trifolium* spp.)	0.5		
Meadowrue (*Thalictrum* spp.)	0.5		
Black medic (*Medicago lupulina*)	0.5		
Brown-eyed Susan (*Rudbeckia hirta*)	0.4		
Major Shrubs (5.4%)			
Wolf willow (*Elaeagnus commutata*)	3.5		
Western snowberry (*Symphyotrichum occidentalis*)	0.9		
Shrubby cinquefoil (*Dasiphora fruticosa*)	0.6		
Rose (*Rosa* spp.)	0.4		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=8)	67 (57-82)	Relative Native (%)	74.1	**Forage Production (kg/ha)**
Clubmoss (n=8)	3 (0-8)	Native Richness	17.1	
Litter (n=8)	67 (52-88)	Relative Exotic (%)	25.9	
Bare soil (n=8)	6 (0-18)	Exotic Richness	5.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=8)	0	Pielou's Evenness Index	0.71	

ML3 – APAD

Exotic *Poa– Hesperostipa spartea / Symphoricarpos occidentalis – Carex*

Exotic Bluegrass – Porcupine-grass / Western Snowberry – Sedge

Moist Loam

(n=6) This is an altered community on moist loam which likely occurs on relatively drier sub-irrigated sites and likely shares similar origins to communities dominated by big bluestem, although this remain unknown. Non-native bluegrass has replaced later seral grasses like porcupine-grass and shrub encroachment is likely.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=5)	% Relative (n=6)
Major Graminoids (71.7%)			
Exotic bluegrass (*Poa* spp.)	18	25.1	24.1
Porcupine-grass (*Hesperostipa spartea*)	23.4	10.8	13
Sedge (*Carex* spp.)	38	9.8	11.9
Green needlegrass (*Nassella viridula*)	0	6.2	5.5
Western wheatgrass (*Pascopyrum smithii*)	0	6	5.2
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	3	2.8	3
Blue grama (*Bouteloua gracilis*)	0	1.7	1.7
Tickle hairgrass (*Agrostis scabra*)	7.4	0	1.2
Needle and threadgrass (*Hesperostipa comata*)	0	1.3	1.2
Undifferentiated graminoids	0	1.2	1
Prairie dropseed (*Sporobolus heterolepis*)	0	1.2	0.9
Smooth brome (*Bromus inermis*)	0	1	0.8
Mat muhly (*Muhlenbergia richardsonis*)	0	0.7	0.5
Junegrass (*Koeleria macrantha*)	0	0.5	0.4
Plains reedgrass (*Calamagrostis montanensis*)	0	0.3	0.3
Sandgrass (*Calamovilfa longifolia*)	0	0.1	0.1
Major Forbs (11.9%)			
Undifferentiated forbs	0	9.8	8.4
Fringed sage (*Artemisia frigida*)	0	2.9	2.6
Field mint (*Mentha arvensis*)	2.6	0	0.4
Canada thistle (*Cirsium arvense*)	0	0.2	0.2
Native thistle (*Cirsium* spp.)	1	0	0.2
Prairie crocus (*Pulsatilla patens*)	0.6	0	0.1
Major Shrubs (16.4%)			
Western snowberry (*Symphyotrichum occidentalis*)	0	15.4	13.1
Rose (*Rosa* spp.)	6	2.4	3.0
Willow (*Salix* spp.)	0	0.3	0.3

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	73.8	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	11.2	
Litter (n=0)	-	Relative Exotic (%)	26.2	
Bare soil (n=5)	1 (0-6)	Exotic Richness	1.8	
Lichen (n=5)	9 (0-22)	Shannon's Diversity Index	2.0	
Moss (n=0)	-	Pielou's Evenness Index	0.77	

ML4 – APAD

Andropogon gerardii – Poa pratensis – Symphyotrichum laeve– Rosa

Big Bluestem – Kentucky Bluegrass – Smooth Blue Aster – Rose

Moist Loam

(n=12) An altered moist loam community retaining dominance of big bluestem which is likely a dominant grass in the potential reference plant community. Disturbance and high soil moisture result in the emergence of exotic species and Kentucky bluegrass invasion. Similar dominant species are present in **ML2** divergent species composition attributed to native forbs and shrubs. Herbaceous cover is low for a big bluestem stand and litter cover is high, indicative of lowered productivity.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=12)	% Relative (n=12)
Major Graminoids (68.6%)			
Big bluestem (*Andropogon gerardii*)		15.2	52.4
Kentucky bluegrass (*Poa pratensis*)		4.6	15.9
Sedge (*Carex* spp.)		0.1	0.4
Little bluestem (*Schizachyrium scoparium*)		<1	0.1
Switchgrass (*Panicum virgatum*)		<1	0.1
Major Forbs (23.8%)			
Smooth blue aster (*Symphyotrichum laeve*)		1.9	6.6
Native thistle (*Cirsium* spp.)		1.3	4.6
Common alfalfa (*Medicago sativa*)		1.1	3.6
Tufted white prairie aster (*Symphyotrichum ericoides*)		0.8	2.9
Strawberry (*Fragaria virginiana*)		0.4	1.4
Silverleaf scurfpea (*Pediomelum argophyllum*)		0.4	1.3
Brown-eyed Susan (*Rudbeckia hirta*)		0.2	0.7
Prairie sage (*Artemisia ludoviciana*)		0.2	0.6
Pussy toes (*Antennaria* spp.)		0.1	0.5
Dandelion (*Taraxacum officinale*)		0.1	0.3
Milkvetch (*Astragalus* spp.)		0.1	0.3
Black medic (*Medicago lupulina*)		0.1	0.2
Velvety goldenrod (*Solidago mollis*)		<1	0.2
Canada thistle (*Cirsium arvense*)		<1	0.1
Milkweed (*Asclepias* spp.)		<1	0.1
Fringed sage (*Artemisia frigida*)		<1	0.1
Long-fruited thimbleweed (*Anemone cylindrica*)		<1	0.1
Major Shrubs (7.6%)			
Rose (*Rosa* spp.)		1.7	5.8
Western snowberry (*Symphyotrichum occidentalis*)		0.3	1.0
Wolf willow (*Elaeagnus commutata*)		0.1	0.4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=12)	29 (20-46)	Relative Native (%)	79.3	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	13.6	
Litter (n=12)	71 (54-79)	Relative Exotic (%)	20.7	
Bare soil (n=0)	-	Exotic Richness	3.6	
Lichen (n=0)	-	Shannon's Diversity Index	1.6	
Moss (n=0)	-	Pielou's Evenness Index	0.58	

ML5 – APAD

Poa pratensis – Elymus trachycaulus* sbsp. *trachycaulus

Kentucky Bluegrass – Slender Wheatgrass

Moist Loam

(n=16) This native grassland on relatively more mesic sites has been altered by disturbance and increases in non-native Kentucky bluegrass which has replaced slender wheatgrass, a likely dominant in later seral states (**ML1b**). Native forb increasers are abundant and tend to be associated with moisture.

Species Composition	% Biomass (n=5)	% Foliar Cover (n=11)	% Relative (n=16)
Major Graminoids (58.6%)			
Kentucky bluegrass (*Poa pratensis*)	15.1	82.9	27
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	4.2	30.4	9.2
Sedge (*Carex* spp.)	5.3	13.6	5
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	11.8	0.5	3.8
Plains rough fescue (*Festuca hallii*)	5.2	6.9	3.5
Purple oatgrass (*Schizachne purpurascens*)	5.5	0.5	1.8
Fringed brome (*Bromus ciliatus*)	1.6	5.3	1.8
Northern reedgrass (*Calamagrostis stricta* absp. *inexpansa*)	0	5.8	1.3
Tufted hairgrass (*Agrostis scabra*)	0.9	2.4	0.9
Junegrass (*Koeleria macrantha*)	0	2.3	0.6
Richardson's needlegrass (*Achnatherum richardsonii*)	0	1.6	0.5
Major Forbs (38.8%)			
Strawberry (*Fragaria virginiana*)	5.3	7.5	3.6
American vetch (*Vicia americana*)	3.1	10	3.4
Common yarrow (*Achillea millefolium*)	3.5	9.1	3.4
Northern bedstraw (*Galium boreale*)	1.2	9.8	3
White clover (*Trifolium repens*)	7.1	0.6	2.4
Dandelion (*Taraxacum officinale*)	2.6	4.6	1.9
Veiny meadowrue (*Thalictrum venulosum*)	0.1	7	1.8
Prairie sage (*Artemisia ludoviciana*)	1.4	4.5	1.7
Canada goldenrod (*Solidago canadensis*)	0.1	6.6	1.6
Canada anemone (*Anemone canadensis*)	0.3	6	1.6
Smooth blue aster (*Symphyotrichum laeve*)	0	5.5	1.5
Purple peavine (*Lathyrus venosus*)	1.6	3	1.3
Long-stalked chickweed (*Stellaria longipes*)	0	3.2	0.9
Canada thistle (*Cirsium arvense*)	1.3	1.6	0.8
Tall meadowrue (*Thalictrum dasycarpum*)	0	2.6	0.7
Bee balm (*Monarda fistulosa*)	0	2.5	0.7
Cream peavine (*Lathyrus ochroleucus*)	0	1.9	0.5
Hoary puccoon (*Lithospermum canescens*)	0	1.8	0.5
Major Shrubs (2.5%)			
Western snowberry (*Symphyotrichum occidentalis*)	0.3	2.5	0.8
Prickly rose (*Rosa acicularis*)	0	2.1	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=5)	78 (67-88)	Relative Native (%)	67.1	**Forage Production (kg/ha)**
Clubmoss (n=16)	0	Native Richness	26.3	
Litter (n=15)	51 (22-90)	Relative Exotic (%)	32.9	
Bare soil (n=15)	5 (0-28)	Exotic Richness	3	
Lichen (n=0)	-	Shannon's Diversity Index	2.4	
Moss (n=14)	1 (0-17)	Pielou's Evenness Index	0.73	

ML6 – APAD

Carex – Poa pratensis

Sedge – Kentucky Bluegrass

Moist Loam

(n=21) Severely altered community that retains high representation of sedges with high proportions of non-native grasses like Kentucky bluegrass, common timothy, and creeping bentgrass. Despite this, diverse native species attribute to 66% of the composition. Ruderal non-native forbs and noxious weeds may be present.

Species Composition	% Biomass (n=21)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (67.6%)			
Sedge (*Carex* spp.)	21.1		
Kentucky bluegrass (*Poa pratensis*)	16.7		
Common timothy (*Phleum pratense*)	5.3		
Creeping bentgrass (*Agrostis stolonifera*)	4.7		
Western wheatgrass (*Pascopyrum smithii*)	2.6		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.1		
Rush (*Juncus* spp.)	1.4		
Porcupine-grass (*Hesperostipa spartea*)	1.3		
Mat muhly (*Muhlenbergia richardsonis*)	1.2		
Big bluestem (*Andropogon gerardii*)	1.2		
Northern wheatgrass (*Elymus lanceolatus*)	1.1		
Smooth brome (*Bromus inermis*)	0.9		
Foxtail barley (*Hordeum jubatum*)	0.9		
Scratchgrass (*Muhlenbergia asperifolia*)	0.9		
Tufted hairgrass (*Deschampsia cespitosa*)	0.9		
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0.6		
Major Forbs (30.2%)			
Strawberry (*Fragaria virginiana*)	3.8		
Dandelion (*Taraxacum officinale*)	2.7		
Northern bedstraw (*Galium boreale*)	2.3		
Common yarrow (*Achillea millefolium*)	1.5		
Pussy toes (*Antennaria* spp.)	1.5		
Cinquefoil (*Potentilla* spp.)	1.3		
Bastard toadflax (*Comandra umbellata*)	1.1		
Aster (*Symphyotrichum* spp.)	1.1		
Canada thistle (*Cirsium arvense*)	1		
Silverweed cinquefoil (*Argentina ansernia*)	1		
Canada anemone (*Anemone canadensis*)	0.9		
Violet (*Viola* spp.)	0.9		
Fringed loosestrife (*Lysimachia ciliata*)	0.7		
Clover (*Trifolium* spp.)	0.6		
Major Shrubs (2.2%)			
Rose (*Rosa* spp.)	0.7		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=21)	69 (41-81)	Relative Native (%)	66.0	**Forage Production (kg/ha)**
Clubmoss (n=21)	1 (0-5)	Native Richness	18.6	
Litter (n=21)	57 (18-98)	Relative Exotic (%)	34.0	
Bare soil (n=21)	8 (0-27)	Exotic Richness	4.9	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=21)	0	Pielou's Evenness Index	0.78	

ML7 – APAD

Poa pratensis – Carex – Elymus trachycaulus* sbsp. *subsecundus

Kentucky Bluegrass – Sedge – Awned Wheatgrass

Moist Loam

(n=18) This is a moist prairie lowland altered by Kentucky bluegrass from a potential reference plant community abundant in grassland and wetland sedges associated with slender wheatgrass (like **ML1b**). This community is productive with high herbaceous cover.

Species Composition	% Biomass (n=16)	% Foliar Cover (n=2)	% Relative (n=18)
Major Graminoids (61.7%)			
Kentucky bluegrass (*Poa pratensis*)	25.9	14.5	25.4
Sedge (*Carex* spp.)	16.5	0	14.6
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	5.1	0	4.5
Creeping bentgrass (*Agrostis stolonifera*)	2.0	0	1.8
Western wheatgrass (*Pascopyrum smithii*)	1.6	0	1.4
Porcupine-grass (*Hesperostipa spartea*)	1.4	0.5	1.3
Smooth brome (*Bromus inermis*)	1	3.5	1.2
Northern reedgrass (*Calamagrostis stricta* absp. *stricta*)	1	0	0.9
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0.7	2.2	0.9
Starved witch-grass (*Dichanthelium depauperatum*)	0.9	0	0.8
Poverty oatgrass (*Danthonia spicata*)	0.8	0	0.7
Junegrass (*Koeleria macrantha*)	0.8	0.3	0.7
Purple oatgrass (*Schizachne purpurascens*)	0.7	0	0.6
Baltic rush (*Juncus balticus*)	0.6	0	0.5
Big bluestem (*Andropogon gerardii*)	0.5	0.1	0.5
Major Forbs (33.1%)			
Strawberry (*Fragaria virginiana*)	4.2	0.5	3.9
Common yarrow (*Achillea millefolium*)	3.9	1.2	3.7
Northern bedstraw (*Galium boreale*)	2.8	1.9	2.8
Dandelion (*Taraxacum officinale*)	2.8	0	2.5
Goldenrod (*Solidago* spp.)	1.4	1.1	1.3
Aster (*Symphyotrichum* spp.)	1.2	0.4	1.1
American vetch (*Vicia americana*)	1.3	0	1.1
Clover (*Trifolium* spp.)	1.2	0	1.1
Canada thistle (*Cirsium arvense*)	1.1	0	1
Prairie sage (*Artemisia ludoviciana*)	0.7	2.9	1
Tufted white prairie aster (*Symphyotrichum ericoides*)	0.3	5.9	0.9
Smooth blue aster (*Symphyotrichum laeve*)	0.6	0.7	0.7
Stiff goldenrod (*Solidago rigida*)	0.3	2.8	076
White clover (*Trifolium repens*)	0.6	0	0.6
Major Shrubs (5.2%)			
Western snowberry (*Symphyotrichum occidentalis*)	1.4	8.7	2.5
Rose (*Rosa* spp.)	1.4	0	1.3

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=16)	60 (35-75)	Relative Native (%)	64.6	**Forage Production (kg/ha)**
Clubmoss (n=17)	8 (0-85)	Native Richness	22.3	2164 kg/ha
Litter (n=17)	50 (0-95)	Relative Exotic (%)	35.4	
Bare soil (n=6)	6 (0-17)	Exotic Richness	3.6	
Lichen (n=1)	0	Shannon's Diversity Index	2.4	
Moss (n=17)	1 (0-12)	Pielou's Evenness Index	0.77	

ML8 – APAD

Carex – Poa pratensis – Argentina anserina

Sedge – Kentucky Bluegrass – Silverweed Cinquefoil

Moist Loam

(n=8) This is a severely altered community similar to **ML6** however there is further decline of native grass decreasers. Short statured grazing tolerant species, particularly silverweed cinquefoil which tends to increase on disturbed mesic sites. Total herbaceous cover is moderate and bare soil is relatively high.

Species Composition	% Biomass (n=8)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (65.3%)			
Sedge (*Carex* spp.)	19.5		
Exotic bluegrass (*Poa pratensis*)	18.1		
Creeping bentgrass (*Agrostis stolonifera*)	3.1		
Creeping red fescue (*Festuca rubra*)	2.8		
Smooth brome (*Bromus inermis*)	2.5		
Quackgrass (*Elymus repens*)	2		
Baltic rush (*Juncus balticus*)	1.9		
Common timothy (*Phleum pratense*)	1.4		
Scratchgrass (*Muhlenbergia asperifolia*)	1.1		
Green needlegrass (*Nassella viridula*)	1		
Rush (*Juncus* spp.)	1		
Wetland sedge (*Carex* spp.)	0.9		
Spike-rush (*Eleocharis* spp.)	0.9		
Fowl bluegrass (*Poa palustris*)	0.8		
Major Forbs (30.1%)			
Silverweed cinquefoil (*Argentina anserina*)	5.8		
Dandelion (*Taraxacum officinale*)	3.1		
Undifferentiated forbs	2.6		
Pussy toes (*Antennaria* spp.)	1.9		
Groundsel (*Senecio/Packera* spp.)	1.9		
Sow thistle (*Sonchus* spp.)	1.3		
Aster (*Symphyotrichum* spp.)	1.3		
Cinquefoil (*Potentilla* spp.)	1.2		
Strawberry (*Fragaria virginiana*)	1		
Tufted white prairie aster (*Symphyotrichum ericoides*)	1		
Yellow sweet clover (*Melilotus officinalis*)	0.7		
Water-horehound (*Lycopus americanus*)	0.6		
Gentian (*Gentiana / Gentianella* spp.)	0.4		
Native thistle (*Cirsium* spp.)	0.4		
Yellow-eyed grass (*Xyris* spp.)	0.3		
Major Shrubs (4.6%)			
Shrubby cinquefoil (*Dasiphora fruticosa*)	1.9		
Western snowberry (*Symphyotrichum occidentalis*)	1.9		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	48 (36-57)	Relative Native (%)	63.7	**Forage Production (kg/ha)**
Clubmoss (n=6)	16.8 (0-98)	Native Richness	14.4	2247 kg/ha
Litter (n=7)	34 (3-63)	Relative Exotic (%)	36.3	
Bare soil (n=7)	13 (0-47)	Exotic Richness	4.1	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=7)	3 (0-20)	Pielou's Evenness Index	0.76	

ML9 – APAD

Exotic Poa – Carex – Fragaria virginiana

Exotic Bluegrass – Sedge - Strawberry

Moist Loam

(n=8) This is a severely altered grassland where graminoids have been reduced to ~50% of the composition and disturbance / grazing tolerant forbs like strawberry are abundant. This shift is expected to result in reduced palatable forage.

Species Composition	% Biomass (n=7)	% Foliar Cover (n=1)	% Relative (n=8)
Major Graminoids (52.7%)			
Exotic bluegrass (*Poa* spp.)	13.7	56	14.2
Sedge (*Carex* spp.)	10.9	26	10.6
Smooth brome (*Bromus inermis*)	4	0	3.5
Undifferentiated graminoids	3.9	0	3.4
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	3.3	0	2.9
Wheatgrass / Ryegrass (*Elymus* spp.)	3.2	0	2.8
Common timothy (*Phleum pratense*)	2.6	0	2.3
Rush (*Juncus* spp.)	2.4	0	2.1
Plains rough fescue (*Festuca hallii*)	0.9	16	1.4
Fringed brome (*Bromus ciliatus*)	0.2	20	1
Northern reedgrass (*Calamagrostis stricta* absp. *stricta*)	1.1	0	1
Creeping bentgrass (*Agrostis stolonifera*)	0.9	0	0.8
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	17	0.7
Major Forbs (45.0%)			
Strawberry (*Fragaria virginiana*)	7.9	10	7.3
Cinquefoil (*Potentilla* spp.)	3.9	0	3.4
Clover (*Trifolium* spp.)	3.8	0	3.3
Dandelion (*Taraxacum officinale*)	3.8	0.1	3.3
Northern bedstraw (*Galium boreale*)	2.2	22	2.8
Common yarrow (*Achillea millefolium*)	2.7	6	2.6
Canada goldenrod (*Solidago canadensis*)	1.2	21	1.9
American vetch (*Vicia americana*)	2	1	1.8
Black medic (*Medicago lupulina*)	1.7	0	1.4
Milkvetch (*Astragalus* spp.)	1.2	0	1
Goldenrod (*Solidago* spp.)	1.2	0	1
Pussy toes (*Antennaria* spp.)	1.1	0	1
Canada anemone (*Anemone canadensis*)	0.3	16	0.9
Prairie crocus (*Pulsatilla patens*)	1	0	0.9
Veiny meadowrue (*Thalictrum venulosum*)	0	17	0.7
Hoary puccoon (*Lithospermum canescens*)	0	15	0.6
Purple peavine (*Lathyrus venosus*)	0.4	6	0.6
Major Shrubs (2.3%)			
Rose (*Rosa* spp.)	0.9	0	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	77 (45-85)	Relative Native (%)	68.1	**Forage Production (kg/ha)**
Clubmoss (n=8)	3 (0-18)	Native Richness	19.9	
Litter (n=8)	37 (13-70)	Relative Exotic (%)	31.9	
Bare soil (n=8)	9 (0-19)	Exotic Richness	5	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=8)	0	Pielou's Evenness Index	0.79	

ML9M (Modified) – APAD

Agrostis stolonifera – Poa pratensis – Carex

Creeping bentgrass – Kentucky Bluegrass – Sedge

Moist Loam

(n=9) This is a **Modified** native grassland on moist loam where non-native grasses like creeping bentgrass and Kentucky bluegrass have increased with disturbance. Native grass decreasers persist in small amounts, recovery is unlikely without significant intervention. Herbaceous cover and relative graminoid abundance is high, unpalatable forbs are low.

Species Composition	% Biomass (n=9)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (81.1%)			
Creeping bentgrass (*Agrostis stolonifera*)	29		
Kentucky bluegrass (*Poa pratensis*)	26.2		
Grassland sedge (*Carex* spp.)	13.9		
Common timothy (*Phleum pratense*)	2.6		
Smooth brome (*Bromus inermis*)	2.3		
Big bluestem (*Andropogon gerardii*)	1.7		
Rush (*Juncus* spp.)	1.5		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	0.8		
Quackgrass (*Elymus repens*)	0.8		
Switchgrass (*Panicum virgatum*)	0.6		
Poverty oatgrass (*Danthonia spicata*)	0.5		
Plains reedgrass (*Calamagrostis montanensis*)	0.4		
Major Forbs (15.8%)			
Clover (*Trifolium* spp.)	2.4		
Goldenrod (*Solidago* spp.)	1.5		
Dandelion (*Taraxacum officinale*)	1.3		
Northern bedstraw (*Galium boreale*)	1.1		
Pussy toes (*Antennaria* spp.)	1		
American vetch (*Vicia americana*)	0.9		
Black medic (*Medicago lupulina*)	0.8		
Aster (*Symphyotrichum* spp.)	0.8		
Common yarrow (*Achillea millefolium*)	0.6		
Strawberry (*Fragaria virginiana*)	0.6		
Wild licorice (*Glycyrrhiza lepidota*)	0.5		
Violet (*Viola* spp.)	0.5		
Common plantain (*Plantago major*)	0.4		
Major Shrubs (2.3%)			
Western snowberry (*Symphyotrichum occidentalis*)	1.1		
Rose (*Rosa* spp.)	0.9		
Other (0.8%)			
Horsetail (*Equisetum* spp.)	0.8		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=9)	72 (50-84)	Relative Native (%)	33.2	**Forage Production (kg/ha)**
Clubmoss (n=9)	0 (0-0.3)	Native Richness	13.4	
Litter (n=9)	50 (33-82)	Relative Exotic (%)	66.8	
Bare soil (n=9)	8 (3-11)	Exotic Richness	6.2	
Lichen (n=0)	-	Shannon's Diversity Index	1.9	
Moss (n=9)	0	Pielou's Evenness Index	0.65	

ML10M (Modified) – APAD

Poa pratensis – Taraxacum officinale – Elymus repens

Kentucky Bluegrass – Dandelion - Quackgrass

Moist Loam

(n=8) This **Modified** grassland represents further alteration from **ML9M** including increases in disturbance tolerant non-native grasses like Kentucky bluegrass, quackgrass, and smooth brome. Disturbance tolerant non-native forbs, primarily dandelion, have significantly increased. Forbs comprise nearly 40% of the composition and are generally disturbance tolerant.

Species Composition	% Biomass (n=8)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (62.1%)			
Kentucky bluegrass (*Poa pratensis*)	30.8		
Quackgrass (*Elymus repens*)	7.6		
Smooth brome (*Bromus inermis*)	7.5		
Creeping bentgrass (*Agrostis stolonifera*)	7.4		
Grassland sedge (*Carex* spp.)	2.9		
Porcupine-grass (*Hesperostipa spartea*)	1.6		
Canary reedgrass (*Phalaris arundinacea*)	1.3		
Wetland sedge (*Carex* spp.)	0.8		
Baltic rush (*Juncus balticus*)	0.6		
Fowl bluegrass (*Poa palustris*)	0.6		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	0.3		
Major Forbs (37.1%)			
Dandelion (*Taraxacum officinale*)	20.3		
White clover (*Trifolium repens*)	3.6		
Silverweed cinquefoil (*Argentina anserina*)	2.5		
Black medic (*Medicago lupulina*)	1.3		
Canada violet (*Viola canadensis*)	1.3		
Aster (*Symphyotrichum* spp.)	0.9		
Canada thistle (*Cirsium arvense*)	0.8		
Common plantain (*Plantago major*)	0.8		
Strawberry (*Fragaria virginiana*)	0.8		
Yellow sweet clover (*Melilotus officinalis*)	0.6		
Undifferentiated forbs	0.5		
Sow thistle (*Sonchus* spp.)	0.5		
Lindley's aster (*Symphyotrichum ciliolatum*)	0.5		
Northern bedstraw (*Galium boreale*)	0.3		
Canada anemone (*Anemone canadensis*)	0.3		
Canada goldenrod (*Solidago canadensis*)	0.3		
Large-leaf avens (*Geum macrophyllum*)	0.3		
Major Shrubs (0.8%)			
Western snowberry (*Symphyotrichum occidentalis*)	0.3		
White meadow-sweet (*Spiraea alba*)	0.3		

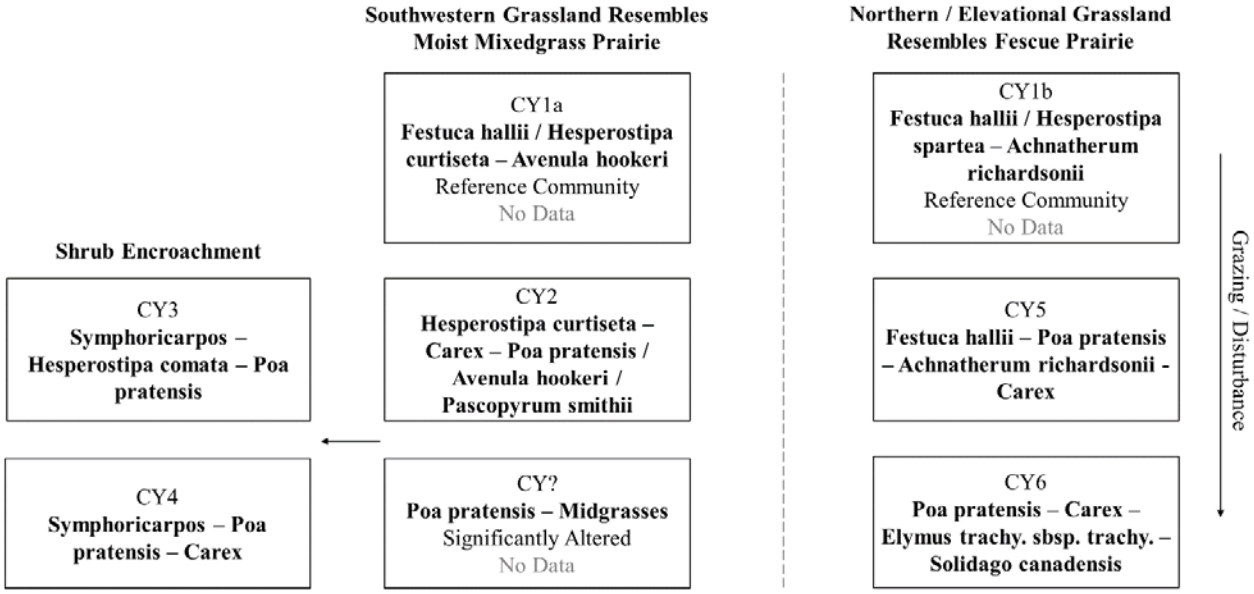
Structure	%	Origin and Diversity		Productivity
Herbaceous (n=8)	64 (38-92)	Relative Native (%)	37.2	**Forage Production (kg/ha)**
Clubmoss (n=2)	8 (0-17)	Native Richness	8.6	2137 kg/ha
Litter (n=8)	40 (8-71)	Relative Exotic (%)	62.8	
Bare soil (n=8)	6 (0-38)	Exotic Richness	6.3	
Lichen (n=0)	-	Shannon's Diversity Index	1.7	
Moss (n=8)	2 (0-17)	Pielou's Evenness Index	0.64	

Clay (CY) – APAD

State-and-Transition Diagram

Grassland

Potential reference plant community was not identified.



Description of Clay S&T

Currently, limited data exists for Clay and many of these plant communities are provisional. Plant communities on Loam are comparable in composition. Clay soils are fine textured resulting in higher water holding capacity and tend to be imperfectly drained, even in uplands although well drained soils can occur. Thus, Clay tends to have plants indicative of moist soil. Plant community data sourced from Clay ecosites represent two extremes of the Aspen Parkland with data from Riding Mountain National Park resembling northern fescue prairie and pastures from south eastern Saskatchewan near the Manitoba boarder resembling moist mixed grassland. Hence, differential communities and their trajectory were described separately until data from the intermediate zone is collected. In later seral communities western porcupine-grass (*Hesperostipa curtiseta*) or porcupine-grass (*Hesperostipa spartea*) are likely codominant or potentially dominant in association with plains rough fescue (*Festuca hallii*), depending on location (**CY1a** and **CY1b**). Porcupine-grass becomes more abundant northward towards the boreal and eastward towards tallgrass prairie. Disturbed plant communities on Clay are susceptible to Kentucky bluegrass (*Poa pratensis*) invasion. Brush encroachment is also responsible for grassland alteration, this could result from high soil moisture or management.

CY1a – APAD

Festuca hallii / Hesperostipa curtiseta – Avenula hookeri

Plains Rough Fescue / Western Porcupine-grass – Midgrasses

Clay

NO DATA

(n=0) In the south western Aspen Parkland, the potential reference plant community established on clay would consist predominantly of plains rough fescue (*Festuca hallii*) in association with western porcupine-grass (*Hesperostipa curtiseta*). The expected composition would be comparable to **LM1** for Loam. Species indicative of moisture may be present.

CY1b – APAD

Festuca hallii / Hesperostipa spartea – Achnatherum richardsonii

Plains Rough Fescue / Porcupine-grass - Midgrasses

Clay

NO DATA

(n=0) For elevated or northern grasslands in the Aspen Parkland potential reference plant communities established on clayey soils would consist predominantly of plains rough fescue (*Festuca hallii*) in association with grass decreasers porcupine-grass (*Hesperostipa spartea*) and Richardson's needlegrass (*Achnatherum richardsonii*). The expected composition would be comparable to **LM8** for Loam. Species indicative of moisture may be present.

CY2 – APAD

Hesperostipa curtiseta – Carex – Poa pratensis – Avenula hookeri – Pascopyrum smithii

Western Porcupine-grass – Sedge – Kentucky Bluegrass – Hooker's Oatgrass – Western Wheatgrass

Clay

(n=2) This is a moderately altered community from **CY1a**, decreaser grasses expected in the reference plant community are reduced by increases in upland sedges increasers and Kentucky bluegrass. Western porcupine-grass remains dominant. Herbaceous cover and litter cover are moderately high, while bare ground is low. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=2)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (88.1%)			
Western porcupine-grass (*Hesperostipa curtiseta*)	25		
Sedge (*Carex* spp.)	9.3		
Kentucky bluegrass (*Poa pratensis*)	8.8		
Hooker's oatgrass (*Avenula hookeri*)	8.5		
Western wheatgrass (*Pascopyrum smithii*)	8.5		
Blue grama (*Bouteloua gracilis*)	7.5		
Green needlegrass (*Nassella viridula*)	5.3		
Plains rough fescue (*Festuca hallii*)	5		
Plains muhly (*Muhlenbergia cuspidata*)	3.3		
Junegrass (*Koeleria macrantha*)	2.3		
Intermediate oatgrass (*Danthonia intermedia*)	2		
Porcupine-grass (*Hesperostipa spartea*)	1.8		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	0.7		
Ticklegrass (*Agrostis scabra*)	0.2		
Major Forbs (10.1%)			
Fringed sage (*Artemisia frigida*)	3.8		
Prairie crocus (*Pulsatilla patens*)	2.8		
Goldenrod (*Solidago* spp.)	1		
Common yarrow (*Achillea millefolium*)	0.8		
Hairy golden aster (*Heterotheca villosa*)	0.8		
Broomweed (*Gutierrezia sarothrae*)	0.5		
American vetch (*Vicia americana*)	0.2		
Cinquefoil (*Potentilla* spp.)	0.2		
Major Shrubs (1.8%)			
Western snowberry (*Symphoricarpos occidentalis*)	1		
Rose (*Rosa* spp.)	0.8		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=2)	63 (40-85)	Relative Native (%)	91.2	**Forage Production (kg/ha)**
Clubmoss (n=2)	6 (0-12)	Native Richness	15	
Litter (n=2)	67 (45-88)	Relative Exotic (%)	8.8	
Bare soil (n=2)	2 (0-4)	Exotic Richness	0.5	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=1)	0	Pielou's Evenness Index	0.80	

CY3 – APAD

Symphoricarpos occidentalis – Hesperostipa comata – Poa pratensis

Western Snowberry – Needle and Threadgrass – Kentucky Bluegrass

Clay

(n=2) This community has been altered by shrub encroachment from western snowberry and wolf willow. Later seral grass decreasers are replaced by needle and threadgrass and other native graminoid increasers. Moisture or disturbance has also resulted in increased bluegrass abundance. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=2)	% Relative (n=2)
Major Graminoids (52.3%)			
Needle and threadgrass (*Hesperostipa comata*)		16	14.7
Kentucky bluegrass (*Poa pratensis*)		9.7	9
Sedge (*Carex* spp.)		6.2	5.8
Green needlegrass (*Nassella viridula*)		5.7	5.3
Junegrass (*Koeleria macrantha*)		5.7	5.3
Western wheatgrass (*Pascopyrum smithii*)		5	4.6
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		2.5	2.3
Northern wheatgrass (*Elymus lanceolatus*)		2	1.8
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		1.5	1.4
Western porcupine-grass (*Hesperostipa curtiseta*)		1.5	1.4
Blue grama (*Bouteloua gracilis*)		0.5	0.5
Plains rough fescue (*Festuca hallii*)		0.3	0.2
Major Forbs (12.7%)			
Undifferentiated forbs		6.2	5.7
Fringed sage (*Artemisia frigida*)		2	1.8
Northern bedstraw (*Galium boreale*)		2	1.8
Prairie sage (*Artemisia ludoviciana*)		1.2	1.1
Pussy toes (*Antennaria* spp.)		1.2	1.1
Common yarrow (*Achillea millefolium*)		0.5	0.5
Dandelion (*Taraxacum officinale*)		0.3	0.2
Locoweed (*Oxytropis* spp.)		0.3	0.2
Cinquefoil (*Potentilla* spp.)		0.3	0.2
Major Shrubs (35.0%)			
Western snowberry (*Symphoricarpos occidentalis*)		29.3	27
Wolf willow (*Elaeagnus commutata*)		7.2	6.6
Rose (*Rosa* spp.)		1.5	1.4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	90.8	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	17.5	
Litter (n=0)	-	Relative Exotic (%)	9.2	
Bare soil (n=0)	-	Exotic Richness	1.5	
Lichen (n=0)	-	Shannon's Diversity Index	2.4	
Moss (n=0)	-	Pielou's Evenness Index	0.81	

CY4 – APAD

Symphoricarpos occidentalis – Poa pratensis – Carex

Western Snowberry – Kentucky Bluegrass – Sedge

Clay

(n=5) This is a significantly altered community with relatively high Kentucky bluegrass and encroachment from western snowberry and wolf willow. Native grasses are reduced from **CY3**. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=5)	% Relative (n=5)
Major Graminoids (50.0%)			
Kentucky bluegrass (*Poa pratensis*)		14.3	16.5
Sedge (*Carex* spp.)		7.2	8.4
Needle and threadgrass (*Hesperostipa comata*)		5.4	6.3
Green needlegrass (*Nassella viridula*)		3.5	4.1
Western porcupine-grass (*Hesperostipa curtiseta*)		2.3	2.7
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		2.1	2.4
Northern wheatgrass (*Elymus lanceolatus*)		1.6	1.9
Junegrass (*Koeleria macrantha*)		1.3	1.6
Western wheatgrass (*Pascopyrum smithii*)		1.3	1.5
Blue grama (*Bouteloua gracilis*)		1.2	1.4
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.9	1
Sand dropseed (*Sporobolus cryptandrus*)		0.4	0.5
Fringed brome (*Bromus ciliatus*)		0.4	0.5
Prairie muhly (*Muhlenbergia cuspidata*)		0.3	0.4
Mat muhly (*Muhlenbergia richardsonis*)		0.2	0.2
Plains rough fescue (*Festuca hallii*)		0.1	0.1
Major Forbs (15.5%)			
Undifferentiated forbs		4.8	5.5
Prairie sage (*Artemisia ludoviciana*)		2.6	3
Northern bedstraw (*Galium boreale*)		1.8	2.1
Fringed sage (*Artemisia frigida*)		1.7	2
Common yarrow (*Achillea millefolium*)		1.1	1.3
Silverleaf scurf pea (*Pediomelum argophyllum*)		0.4	0.5
Locoweed (*Oxytropis* spp.)		0.2	0.2
Canada thistle (*Cirsium arvense*)		0.2	0.2
Vetch (*Vicia* spp.)		0.2	0.2
Pussy toes (*Antennaria* spp.)		0.1	0.1
Major Shrubs (34.5%)			
Western snowberry (*Symphoricarpos occidentalis*)		23.7	27.4
Wolf willow (*Elaeagnus commutata*)		5.9	6.8
Rose (*Rosa* spp.)		1	1.1
Saskatoon (*Amelanchier alnifolia*)		0.3	0.3

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	83	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	16	
Litter (n=0)	-	Relative Exotic (%)	17	
Bare soil (n=0)	-	Exotic Richness	1.2	
Lichen (n=0)	-	Shannon's Diversity Index	2.3	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

CY5 – APAD

Festuca hallii – Poa pratensis – Achnatherum richardsonii – Carex

Plains Rough Fescue – Kentucky Bluegrass – Richardson's Needlegrass - Sedge

Clay

(n=2) Altered community dominated by plains rough fescue with exotic Kentucky bluegrass displacing needlegrass decreasers expected in **CY1b**. Despite reductions, diverse abundant grass decreasers remain giving this stand potential for recovery. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=2)	% Relative (n=2)
Major Graminoids (71.5%)			
Plains rough fescue (*Festuca hallii*)		61	29.6
Kentucky bluegrass (*Poa pratensis*)		29.5	14.3
Richardson's needlegrass (*Achnatherum richardsonii*)		15.5	7.5
Sedge (*Carex* spp.)		14.5	7
Porcupine-grass (*Hesperostipa spartea*)		9.5	4.6
Junegrass (*Koeleria macrantha*)		8.5	4.1
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		2.5	1.2
Fringed brome (*Bromus ciliatus*)		1.5	0.7
Purple oatgrass (*Schizachne purpurascens*)		1	0.5
Hooker's oatgrass (*Avenula hookeri*)		1	0.5
Major Forbs (25.7%)			
Northern bedstraw (*Galium boreale*)		10.5	5.1
American vetch (*Vicia americana*)		5.5	2.7
Bee balm (*Monarda fistulosa*)		5.5	2.7
Prairie smoke (*Geum triflorum*)		4.5	2.2
Veiny meadowrue (*Thalictrum venulosum*)		3.5	1.7
Tufted white prairie aster (*Symphyotrichum ericoides*)		3.5	1.7
Stiff goldenrod (*Solidago rigida*)		2.5	1.2
Smooth blue aster (*Symphyotrichum laeve*)		2.5	1.2
Smooth fleabane (*Erigeron glabellus*)		2.5	1.2
Strawberry (*Fragaria virginiana*)		2	1
Prairie sage (*Artemisia ludoviciana*)		1.6	0.8
Hoary puccoon (*Lithospermum canescens*)		1.1	0.5
Common yarrow (*Achillea millefolium*)		1	0.5
Missouri goldenrod (*Solidago missouriensis*)		1	0.5
Meadowrue (*Thalictrum dasycarpum*)		1	0.5
Cream peavine (*Lathyrus ochroleucus*)		1	0.5
Prairie alumroot (*Heuchera richardsonii*)		1	0.5
Long-fruited thimbleweed (*Anemone cylindrica*)		1	0.5
Purple peavine (*Lathyrus venosus*)		0.6	0.3
Major Shrubs (2.8%)			
Prickly rose (*Rosa acicularis*)		5.6	2.7
Western snowberry (*Symphoricarpos occidentalis*)		1	0.5

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	86.5	**Forage Production (kg/ha)**
Clubmoss (n=2)	0	Native Richness	33	
Litter (n=2)	50 (43-57)	Relative Exotic (%)	13.5	
Bare soil (n=2)	0	Exotic Richness	1.5	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=2)	4 (0-8)	Pielou's Evenness Index	0.70	

CY6 – APAD

Poa pratensis – Carex – Elymus trachycaulus* subsp. *trachycaulus / Solidago canadensis

Kentucky Bluegrass – Sedge – Slender Wheatgrass – Canada Goldenrod

Clay

(n=3) This is a significantly altered fescue prairie. Increases of Kentucky bluegrass associated with Canada goldenrod, slender wheatgrass, and fringed brome are indicative of the imperfectly drained soils characteristic of Clay. Relative to **CY5** forbs are more abundant (near 50%), litter cover is relatively low and bare soil has increased. Due to limited data this is a provisional community.

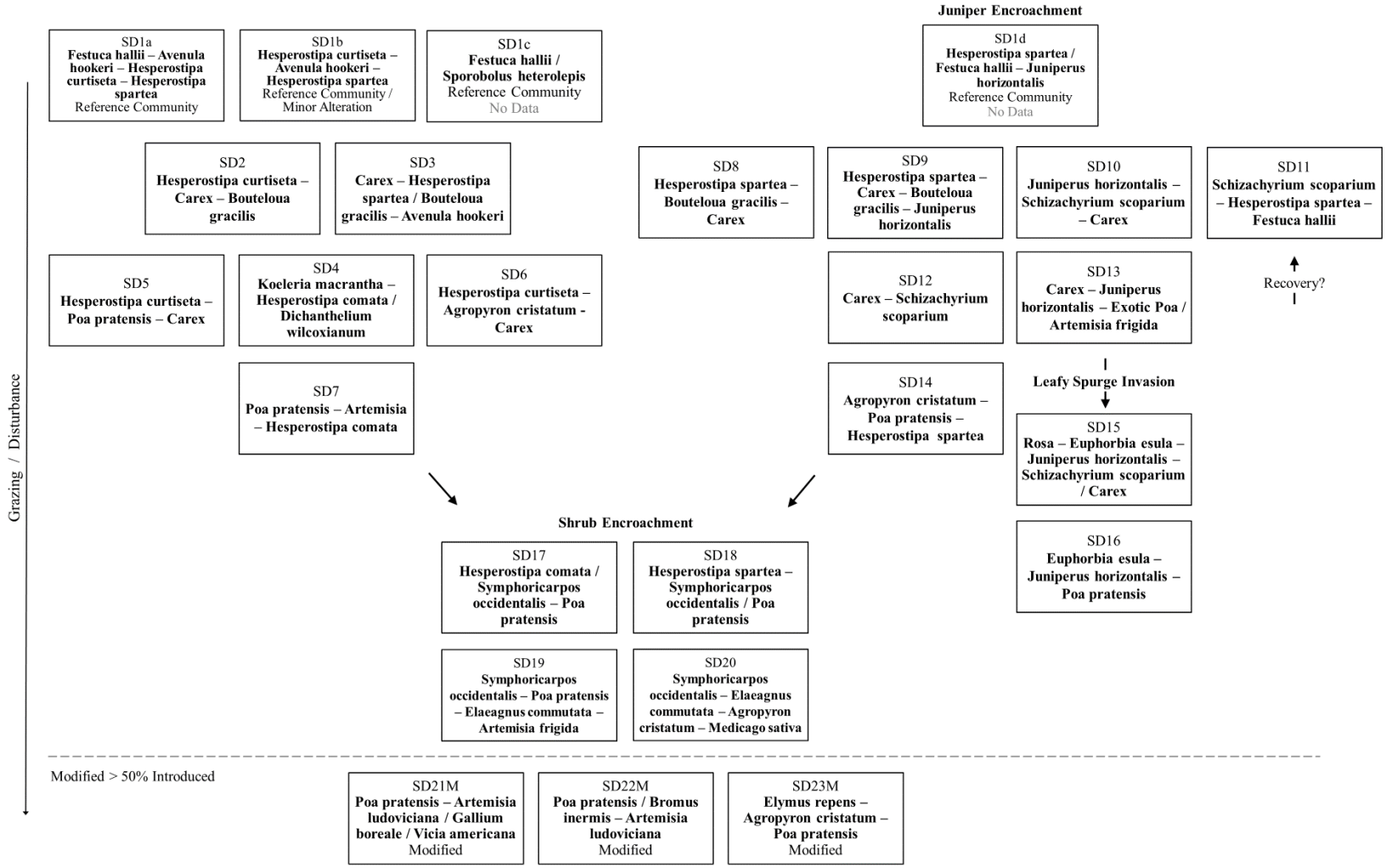
Species Composition	% Biomass (n=0)	% Foliar Cover (n=3)	% Relative (n=3)
Major Graminoids (51.6%)			
Kentucky bluegrass (*Poa pratensis*)		72	24.1
Sedge (*Carex* spp.)		28.3	9.5
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		15.3	5.2
Fringed brome (*Bromus ciliatus*)		10.7	3.6
Plains rough fescue (*Festuca hallii*)		7	2.3
Smooth brome (*Bromus inermis*)		3.7	1.2
Slough sedge (*Carex atherodes*)		2.7	0.9
Porcupine-grass (*Hesperostipa spartea*)		2	0.7
Purple oatgrass (*Schizachne purpurascens*)		1.7	0.6
Marsh muhly (*Muhlenbergia racemosa*)		1.7	0.6
Major Forbs (47.7%)			
Canada goldenrod (*Solidago canadensis*)		28.3	9.5
Meadowrue (*Thalictrum dasycarpum*)		15.3	5.1
Smooth blue aster (*Symphyotrichum laeve*)		13.7	4.6
Northern bedstraw (*Galium boreale*)		13	4.4
Fringed loosestrife (*Lysimachia ciliata*)		9.3	3.1
Strawberry (*Fragaria virginiana*)		9	3
Anise hyssop (*Agastache foeniculum*)		7.4	2.5
American vetch (*Vicia americana*)		5.3	1.8
Purple peavine (*Lathyrus venosus*)		5.3	1.8
Prairie sage (*Artemisia ludoviciana*)		5	1.7
Canada anemone (*Anemone canadensis*)		5	1.7
Aster (*Symphyotrichum* spp.)		5	1.7
Common yarrow (*Achillea millefolium*)		4	1.3
Cream peavine (*Lathyrus ochroleucus*)		4	1.3
Marsh hedge-nettle (*Stachys palustris*)		3.7	1.2
Star flowered false Solomon's seal (*Maianthemum stellatum*)		3.7	0.8
Meadowrue (*Thalictrum venulosum*)		2.4	0.8
Tall bluebells (*Mertensia paniculata*)		2	0.7
Bee balm (*Monarda fistulosa*)		1.3	0.4
Major Shrubs (0.7%)			
Prickly rose (*Rosa acicularis*)		0.7	0.2

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	73.9	**Forage Production (kg/ha)**
Clubmoss (n=3)	0	Native Richness	33	
Litter (n=3)	39 (11-60)	Relative Exotic (%)	26.1	
Bare soil (n=3)	8 (3-16)	Exotic Richness	2	
Lichen (n=0)	-	Shannon's Diversity Index	2.6	
Moss (n=3)	0	Pielou's Evenness Index	0.74	

Sand (SD) – APAD
State-and-Transition Diagram

Grassland

Includes coarse-textured soils with gravel (GR).



Description of Sand State and Transition Diagram

Our sand plant community data are very complex, with trends in climate, disturbance, encroachment of juniper or snowberry, and invasions of non-native bluegrass and leafy spurge. Whether a plant community is dominated or co-dominated by porcupine or western porcupine grass **(SD1a** and **SD1b)** seems to depend on climate and moisture gradients in the Aspen Parkland, where moisture increases toward the boreal transition to the north and tallgrass prairie to the east. These communities respond similarly to disturbance, with increases in grazing tolerant native graminoids like sedges, blue grama, and junegrass (see **SD2** and **SD8**). For sand, increases in porcupine-grass dominance also tended to coincide with increases in juniper, which is often represented on stabilized flat sand deposits in the Assiniboine Delta. Communities **SD8** to **SD16** are more likely to occur in the Assiniboine Delta, however data from sand deposits throughout the Aspen Parkland also contributed to their composition.

A plains rough fescue / prairie dropseed community **(SD1c)** was observed on sands near Rivers Provincial Park and is expected to occur on similar elevational, well drained soils where there has been a history of low disturbance. Currently there is no quantitative data support any mid or later seral communities related to it. Prairie dropseed was typically detected in minor amounts.

Juniper naturally exists on sand in small amounts, as it serves an important function in stabilizing exposed or eroded soil surfaces. On dunes, where risk of soil surface destabilization is higher, juniper has relatively higher cover. Juniper cover could increase on sand where disturbances like grazing result in greater exposed soil. Juniper encroachment appears to be associated with a new stable state (see S&T and ordination) where the expected reference plant community **(SD1d)** contains similar later seral herbaceous species as found in **SD1a** and **SD1b**, but with relatively lower herbaceous productivity or cover. Later seral species seem to be protected from grazing by the cover of juniper. We don't have any burn data to support what happens to these later seral recovery communities when the juniper is effectively taken away.

Non-native bluegrasses tend to increase on landscapes with a history of intense or prolonged disturbance and is known to increase with grazing pressure. Competitiveness of bluegrass is likely limited in part by the aridity of this ecosite, favoring increases in native graminoid increasers. Communities containing exotic forages like crested wheatgrass, smooth brome, and alfalfa were likely disturbed and seeded at some point. Where these forages occur in communities dominated by native plants it could represent failed establishment due to aridity or other factors. Communities **SD19** and **SD20** suggest these forage-dominated herbaceous stands may be susceptible to brush encroachment.

Available data shows that plant communities on sand are also susceptible to invasion from leafy spurge (**SD15** and **SD16)**, becoming dominant in severely altered communities containing a creeping juniper understory and compromised cover grass decreasers. In our data, communities dominated by invasive weeds often shifted towards monoculture and lack the ecological functions modified or tame communities provide.

SD1a – APAD

Festuca hallii – Avenula hookeri – Hesperostipa curtiseta – Hesperostipa spartea

Plains Rough Fescue – Hooker's Oatgrass – Western Porcupine-grass – Porcupine-grass

Sand

(n=6) This **reference plant community** for sand is dominated by grasses sensitive to disturbance and overgrazing, primarily plains rough fescue, Hooker's oatgrass, and porcupine grasses. Disturbance-induced increaser plants are present in relatively small amounts. The minor amount of Kentucky bluegrass in this and other later seral communities indicates some susceptibility of sand to exotic invasion. The soil surface is covered by litter and a substantial soil crust.

Species Composition	% Biomass (n=5)	% Foliar Cover (n=1)	% Relative (n=6)
Major Graminoids (81.2%)			
Plains rough fescue (*Festuca hallii*)	21.6	8.4	20.7
Hooker's oatgrass (*Avenula hookeri*)	15.2	5.6	14.5
Western porcupine-grass (*Hesperostipa curtiseta*)	12.3	0	10.3
Porcupine-grass (*Hesperostipa spartea*)	6.7	8	8.2
Junegrass (*Koeleria macrantha*)	5.4	5	6.1
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	6.7	0	5.6
Grassland sedge (*Carex* spp.)	5.2	0	4.4
Little bluestem (*Schizachyrium scoparium*)	4.9	0	4.1
Blue grama (*Bouteloua gracilis*)	2.3	4	3.2
Sheep fescue (*Festuca saximontana*)	1.6	1.4	1.8
Kentucky bluegrass (*Poa pratensis*)	1.3	0	1.1
Low sedge (*Carex duriuscula*)	0	3	1
Major Forbs (19.8%)			
Northern bedstraw (*Galium boreale*)	2	1.1	2.1
Sunflower (*Helianthus* spp.)	2.2	0	1.8
Prairie crocus (*Pulsatilla patens*)	1	2.1	1.5
Bastard toadflax (*Comandra umbellata*)	1.8	0	1.5
Prairie smoke (*Geum triflorum*)	1.6	0	1.3
Common yarrow (*Achillea millefolium*)	0.7	1.4	1
Purple prairie clover (*Dalea purpurea*)	0.8	1.1	1
Fringed sage (*Artemisia frigida*)	0.2	2.6	1
Blue-eyed grass (*Sisyrinchium montanum*)	0.8	0	0.6
False dandelion (*Agoseris glauca*)	0.2	1.3	0.6
Cut-leaved anemone (*Anemone multifida*)	0.7	0	0.6
Chickweed (*Cerastium arvense*)	0.1	1.5	0.6
Narrow-leaved milkvetch (*Astragalus pectinatus*)	0.6	0	0.5
Yellow owl-clover (*Orthocarpus luteus*)	0	1.5	0.5
Tufted white prairie aster (*Symphyotrichum ericoides*)	0	1.5	0.5
Harebell (*Campanula rotundifolia*)	0.5	0	0.4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=4)	57 (48-74)	Relative Native (%)	98.9	**Forage Production (kg/ha)**
Clubmoss (n=5)	7 (0-26)	Native Richness	27	
Litter (n=5)	38 (0-60)	Relative Exotic (%)	1.1	
Bare soil (n=4)	0	Exotic Richness	0.9	
Lichen (n=1)	12	Shannon's Diversity Index	2.3	
Moss (n=1)	13	Pielou's Evenness Index	0.79	

SD1b – APAD

Hesperostipa curtiseta – Avenula hookeri – Hesperostipa spartea

Western Porcupine-grass – Hooker's Oatgrass – Porcupine-grass

Sand

(n=16) An alternative potential **reference plant community** with some minimal alteration, dominated by decreaser porcupine grasses. It retains a relatively high proportion of Hooker's oatgrass, and an associate of plains rough fescue. This community could represent some retrogression from the reference plant community **SD1a** or recovery towards it from a moderately altered community. Disturbance-induced increaser plants are present in relatively small amounts. The soil surface is well covered by live plant material and litter.

Species Composition	% Biomass (n=16)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (69.1%)			
Western porcupine-grass (*Hesperostipa curtiseta*)	18.1		
Hooker's oatgrass (*Avenula hookeri*)	11.2		
Porcupine-grass (*Hesperostipa spartea*)	7.5		
Grassland sedge (*Carex* spp.)	5.4		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	4.3		
Junegrass (*Koeleria macrantha*)	4.2		
Sheep fescue (*Festuca saximontana*)	4.1		
Blue grama (*Bouteloua gracilis*)	3.7		
Plains rough fescue (*Festuca hallii*)	2.7		
Sandgrass (*Calamovilfa longifolia*)	1.9		
Little bluestem (*Schizachyrium scoparium*)	1.5		
Kentucky bluegrass (*Poa pratensis*)	1.1		
Low sedge (*Carex duriuscula*)	0.8		
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	0.8		
Major Forbs (31.7%)			
Northern bedstraw (*Galium boreale*)	4.4		
Prairie smoke (*Geum triflorum*)	3.6		
Purple prairie clover (*Dalea purpurea*)	2.4		
Bastard toadflax (*Comandra umbellata*)	2.3		
Prairie crocus (*Pulsatilla patens*)	1.8		
Common yarrow (*Achillea millefolium*)	1.7		
Blue-eyed grass (*Sisyrinchium montanum*)	1.5		
Fringed sage (*Artemisia frigida*)	1.4		
Tufted white prairie aster (*Symphyotrichum ericoides*)	1.2		
Brown-eyed Susan (*Rudbeckia hirta*)	1		
Harebell (*Campanula rotundifolia*)	0.7		
Showy sunflower (*Helianthus laetiflorus*)	0.7		
Gaillardia (*Gaillardia aristata*)	0.7		
Dotted blazing star (*Liatris punctata*)	0.7		
Major Shrubs (0.2%)			

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=16)	51 (40-69)	Relative Native (%)	98.5	**Forage Production (kg/ha)**
Clubmoss (n=16)	12 (0-27)	Native Richness	24	
Litter (n=16)	36 (11-58)	Relative Exotic (%)	1.5	
Bare soil (n=16)	0.2 (0-2)	Exotic Richness	0.8	
Lichen (n=0)	-	Shannon's Diversity Index	2.7	
Moss (n=0)	-	Pielou's Evenness Index	0.85	

SD1c – APAD

Festuca hallii / Sporobolus heterolepis

Plains Rough Fescue / Prairie Dropseed

Sand

(n=0) An alternative potential **reference plant community** on sand (coarse sand or sand with fine gravel) dominated by plains rough fescue (*Festuca hallii*) and prairie dropseed (*Sporobolus heterolepis*) can be assumed for sands based on observations in Rivers Provincial Park on well drained hill tops and gentle slopes with coarse textured soils containing fine gravel. Dominance seems to shift from high amounts of fescue on drier microsites to a greater amount of dropseed in slightly moister microsites. A similar mixture of these two species was casually observed on some open slopes of the Elk Glen property outside of the southwestern edge of Riding Mountain National Park. In the absences of grazing these decreasers become dominant and form obvious tussocks. The community is susceptible to Kentucky bluegrass invasion, which is evident at Rivers Provincial Park.

Image 3. Well developed tussocks of prairie dropseed (*Sporobolus heterolepis*) within plains rough fescue (*Festuca hallii*) and minor amounts of exotic Kentucky bluegrass (*Poa pratensis*) in this picture taken at Rivers Provincial Park.

SD1d – APAD

Hesperostipa spartea / Festuca hallii – Juniperus horizontalis

Porcupine-grass / Plains Rough Fescue – Creeping Juniper

Sand

(n=0) This later seral **alternative reference plant community** was observed frequently, including on flat to moderately hilly sandy-textured prairies from the Ellice-Archie AMCP (Association of Manitoba Community Pastures) pasture on the west side of the Aspen Parkland Rangeland Ecoregion, to sand flats throughout the Assiniboine Delta Rangeland Ecoregion. It is likely derived from the reference plant community **SD1a**, after creeping juniper (*Juniperus horizontalis*) encroachment. Porcupine-grass (*Hesperostipa spartea*) tends to be dominant with co-occurrences of strong decreasers like plains rough fescue (*Festuca hallii*) and Hooker's oatgrass (*Avenula hookeri*) with abundant creeping juniper remaining under grass leaves and litter. The presence of plains rough fescue, an extremely sensitive decreaser, appears to have been facilitated by juniper, which protects decreaser plants from grazing. Based on observations from Ellice-Archie pasture, western porcupine grass (*Hesperostipa curtiseta*) can be functionally similar to porcupine grass and could be an alternative dominant or co-dominant species (data collection required).

Image 4. A community dominated by plains rough fescue (*Festuca hallii*), creeping juniper *(Juniperus horizontalis)* and bear berry (*Arctostaphylos uva-urs*) on a sand ecosite at Ellice-Archie AMCP Pasture.

SD2 – APAD

Hesperostipa curtiseta – Carex – Bouteloua gracilis

Western Porcupine-grass – Sedge – Blue Grama

Sand

(n=44) Altered community relative to **SD1a** or **SD1b.** Decreasers are abundant, but dominant reference plant community decreaser grasses have been displaced by increases in grazing tolerant upland sedges and blue grama. Total herbaceous cover is also reduced. The soil surface retains a soil crust.

Species Composition	% Biomass (n=41)	% Foliar Cover (n=3)	% Relative (n=44)
Major Graminoids (76.8%)			
Western porcupine-grass (*Hesperostipa curtiseta*)	26.3	28.9	27.6
Grassland sedge (*Carex* spp.)	11.3	6.2	10.8
Blue grama (*Bouteloua gracilis*)	9.6	3	9.5
Hooker's oatgrass (*Avenula hookeri*)	4.8	13.9	5.4
Junegrass (*Koeleria macrantha*)	3.8	3.7	3.7
Sandgrass (*Calamovilfa longifolia*)	2.7	0	2.5
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.2	0.2	2
Sheep fescue (*Festuca saximontana*)	2.1	0	1.9
Needle and threadgrass (*Hesperostipa comata*)	1.7	1	1.8
Porcupine-grass (*Hesperostipa spartea*)	1.8	0	1.7
Northern wheatgrass (*Elymus lanceolatus*)	1.5	0.5	1.5
Low sedge (*Carex duriuscula*)	1.3	0	1.2
Plains muhly (*Muhlenbergia cuspidata*)	1.2	0.5	1.1
Kentucky bluegrass (*Poa pratensis*)	1.1	0.2	1
Northern reedgrass (*Calamagrostis stricta* sbsp. *stricta*)	0.9	0	0.8
Plains rough fescue (*Festuca hallii*)	0.5	5	0.8
Western wheatgrass (*Pascopyrum smithii*)	0.8	0	0.7
Plains reedgrass (*Calamagrostis montanensis*)	0.7	0	0.6
Major Forbs (21.5%)			
Fringed sage (*Artemisia frigida*)	3.3	2.2	3.3
Prairie smoke (*Geum triflorum*)	2.2	0	2
Hairy golden aster (*Heterotheca villosa*)	1.6	0	1.5
Northern bedstraw (*Galium boreale*)	1	4.5	1.2
Bastard toadflax (*Comandra umbellata*)	1.2	0.2	1.1
Harebell (*Campanula rotundifolia*)	1.1	0	1
Prairie sage (*Artemisia ludoviciana*)	0.9	1.7	0.9
Sunflower (*Helianthus* spp.)	0.8	0.2	0.8
Common yarrow (*Achillea millefolium*)	0.9	0.3	0.8
Purple prairie clover (*Dalea purpurea*)	0.6	1.8	0.7
Chickweed (*Cerastium arvense*)	0.8	0	0.7
Prairie crocus (*Pulsatilla patens*)	0.7	0	0.7
Major Shrubs (1.7%)			
Rose (*Rosa* spp.)	1.1	0.5	1.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=29)	44 (29-65)	Relative Native (%)	98.4	**Forage Production (kg/ha)**
Clubmoss (n=30)	24 (0-67)	Native Richness	19.1	
Litter (n=29)	43 (17-81)	Relative Exotic (%)	1.6	
Bare soil (n=29)	4 (0-26)	Exotic Richness	0.5	
Lichen (n=0)	-	Shannon's Diversity Index	2.3	
Moss (n=22)	0	Pielou's Evenness Index	0.79	

SD3 – APAD

Carex – Hesperostipa spartea* / *Bouteloua gracilis – Avenula hookeri

Sedge – Porcupine-grass / Blue Grama – Hooker's Oatgrass

Sand

(n=9) Altered plant community where dominant reference plant community grasses have been displaced by increases in grazing tolerant upland sedges. However, small proportions of decreaser grass species are retained and comprise 30% of the composition. Bare soil exposure is relatively low.

Species Composition	% Biomass (n=9)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (72.7%)			
Grassland sedge (*Carex* spp.)	16.8		
Porcupine-grass (*Hesperostipa spartea*)	7.5		
Blue grama (*Bouteloua gracilis*)	7.2		
Hooker's oatgrass (*Avenula hookeri*)	6.9		
Western porcupine-grass (*Hesperostipa curtiseta*)	6.7		
Plains rough fescue (*Festuca hallii*)	6.4		
Junegrass (*Koeleria macrantha*)	6.2		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	5		
Sandgrass (*Calamovilfa longifolia*)	3.3		
Little bluestem (*Schizachyrium scoparium*)	2.1		
Exotic Poa (*Poa* spp.)	1.4		
Sheep fescue (*Festuca saximontana*)	0.9		
Northern wheatgrass (*Elymus lanceolatus*)	0.6		
Plains reedgrass (*Calamagrostis montanensis*)	0.4		
Major Forbs (23.1%)			
Fringed sage (*Artemisia frigida*)	3		
Northern bedstraw (*Galium boreale*)	2.5		
Prairie smoke (*Geum triflorum*)	2.4		
Bastard toadflax (*Comandra umbellata*)	1.8		
Missouri goldenrod (*Solidago missouriensis*)	1.6		
Harebell (*Campanula rotundifolia*)	1.6		
Blue-eyed grass (*Sisyrinchium montanum*)	1.5		
Hairy golden aster (*Heterotheca villosa*)	1.3		
Common yarrow (*Achillea millefolium*)	1		
Goldenrod (*Solidago* spp.)	1		
Bee balm (*Monarda fistulosa*)	0.9		
Cut-leaved anemone (*Anemone multifida*)	0.7		
Tall cinquefoil (*Potentilla arguta*)	0.7		
Aster (*Symphyotrichum* spp.)	0.6		
Gaillardia (*Gaillardia aristata*)	0.6		
Major Shrubs (4.2%)			
Rose (*Rosa* spp.)	3.4		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	35	Relative Native (%)	98.1	**Forage Production (kg/ha)**
Clubmoss (n=1)	2	Native Richness	22.2	
Litter (n=1)	53	Relative Exotic (%)	1.9	
Bare soil (n=1)	2	Exotic Richness	0.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=1)	0	Pielou's Evenness Index	0.81	

SD4 – APAD

Koeleria macrantha – Hesperostipa comata / Dichanthelium wilcoxianum

Junegrass – Needle and Threadgrass / Wilcox's Panic-grass

Sand

(n=6) This significantly altered community is dominated by grazing tolerant grasses including Junegrass, needle and thread grass, and Wilcox's panic-grass. This alteration was not accompanied by significant increases in exotic species. The plant community remains diverse with representation from some decreaser plants.

Species Composition	% Biomass (n=6)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (77.4%)			
Junegrass (*Koeleria macrantha*)	17.7		
Needle and threadgrass (*Hesperostipa comata*)	9.3		
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	9		
Grassland sedge (*Carex* spp.)	7.7		
Porcupine-grass (*Hesperostipa spartea*)	7.3		
Western porcupine-grass (*Hesperostipa curtiseta*)	7.2		
Blue grama (*Bouteloua gracilis*)	5.9		
Sheep fescue (*Festuca saximontana*)	3.7		
Beaked sedge (*Carex rostrata*)	3.1		
Hooker's oatgrass (*Avenula hookeri*)	2.7		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.6		
Kentucky bluegrass (*Poa pratensis*)	1.5		
Mat muhly (*Muhlenbergia richardsonis*)	1.3		
Plains reedgrass (*Calamagrostis montanensis*)	1.2		
Sandgrass (*Calamovilfa longifolia*)	1		
Prairie sedge (*Carex prairea*)	0.4		
Major Forbs (21.4%)			
Chickweed (*Cerastium arvense*)	3.1		
Prairie crocus (*Pulsatilla patens*)	2.3		
Hairy golden aster (*Heterotheca villosa*)	1.9		
Sunflower (*Helianthus* spp.)	1.7		
Goldenrod (*Solidago* spp.)	1.6		
Harebell (*Campanula rotundifolia*)	1.5		
Milkweed (*Asclepias* spp.)	0.9		
Cinquefoil (*Potentilla* spp.)	0.8		
Blue-eyed grass (*Sisyrinchium montanum*)	0.7		
Bastard toadflax (*Comandra umbellata*)	0.6		
Purple prairie clover (*Dalea purpurea*)	0.6		
Dotted blazing star (*Liatris punctata*)	0.6		
Little rose (*Chamaerhodos erecta*)	0.5		
Major Shrubs (1.2%)			
Rose (*Rosa* spp.)	1.2		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	98.5	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	19.3	
Litter (n=0)	-	Relative Exotic (%)	1.5	
Bare soil (n=0)	-	Exotic Richness	0.3	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=0)	-	Pielou's Evenness Index	0.85	

SD5 – APAD

Hesperostipa curtiseta – Poa pratensis – Carex

Western Porcupine-grass – Kentucky Bluegrass – Sedge

Sand

(n=25) This community likely has a history of significant alteration from previous states (**SD2** or **SD3**). It is dominated by the decreaser western porcupine-grass but with significant amounts of the exotic Kentucky bluegrass. Other exotic species have emerged but occur in very small amounts. Other decreaser grasses are diverse but occur in small amounts. Bare soil and clubmoss are present but not excessive.

Species Composition	% Biomass (n=16)	% Foliar Cover (n=9)	% Relative (n=25)
Major Graminoids (80.5%)			
Western porcupine-grass (*Hesperostipa curtiseta*)	21.1	26.2	25.6
Kentucky bluegrass (*Poa pratensis*)	12	5.5	10.2
Grassland sedge (*Carex* spp.)	8.5	4.7	7.7
Junegrass (*Koeleria macrantha*)	8.2	1.4	6
Hooker's oatgrass (*Avenula hookeri*)	3.7	3	3.4
Needle and threadgrass (*Hesperostipa comata*)	2.3	2.2	2.7
Sand dropseed (*Sporobolus cryptandrus*)	0.7	3.9	2.2
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.2	1.1	2
Russian wildrye (*Psathyrostachys juncea*)	3.1	0	2
Blue grama (*Bouteloua gracilis*)	2.1	1.3	1.9
Porcupine-grass (*Hesperostipa spartea*)	2.9	0	1.9
Sandgrass (*Calamovilfa longifolia*)	0.4	2.7	1.9
Low sedge (*Carex duriuscula*)	2.1	0	1.3
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	2.0	0	1.3
Sheep fescue (*Festuca saximontana*)	1.5	0	0.9
Prairie muhly (*Muhlenbergia cuspidata*)	0.7	1	0.9
Green needlegrass (*Nassella viridula*)	0	1.8	0.9
Western wheatgrass (*Pascopyrum smithii*)	1.3	0.1	0.9
Plains rough fescue (*Festuca hallii*)	0.2	1.4	0.7
Northern wheatgrass (*Elymus lanceolatus*)	0.7	0.3	0.7
Major Forbs (18.0%)			
Fringed sage (*Artemisia frigida*)	4.5	2.9	4.7
Undifferentiated forbs	0.1	4.8	2.2
Northern bedstraw (*Galium boreale*)	1.7	2.4	2.2
Prairie sage (*Artemisia ludoviciana*)	1.9	1.8	2
Prairie smoke (*Geum triflorum*)	2.1	0	1.4
Meadowrue (*Thalictrum* spp.)	0	1.8	0.8
Tufted white prairie aster (*Symphyotrichum ericoides*)	1.1	0	0.7
Major Shrubs (1.5%)			
Rose (*Rosa* spp.)	1.3	0.2	0.9
Western snowberry (*Symphoricarpos occidentalis*)	0.2	1.5	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=10)	52 (33-78)	Relative Native (%)	86.1	**Forage Production (kg/ha)**
Clubmoss (n=10)	9 (0-21)	Native Richness	15.3	
Litter (n=10)	49 (29-69)	Relative Exotic (%)	13.9	
Bare soil (n=10)	5 (0-16)	Exotic Richness	1.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=2)	0	Pielou's Evenness Index	0.80	

SD6 – APAD

Hesperostipa curtiseta – Agropyron cristatum – Carex

Western Porcupine-grass – Crested Wheatgrass – Sedge

Sand

(n=3) This plant community is severely altered. It is possible this community was seeded, in part, with crested wheatgrass, but has become a mix of native and exotic cover with the recovery of a key decreaser, western porcupine grass. Relative representation of exotic species is ~30%. Relative to previous states there is greater herbaceous cover and lower soil crust cover.

Species Composition	% Biomass (n=3)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (88.7%)			
Western porcupine-grass (*Hesperostipa curtiseta*)	30		
Crested wheatgrass (*Agropyron cristatum*)	22.7		
Grassland sedge (*Carex* spp.)	8.7		
Junegrass (*Koeleria macrantha*)	4.7		
Blue grama (*Bouteloua gracilis*)	4.2		
Kentucky bluegrass (*Poa pratensis*)	4		
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	3.3		
Porcupine-grass (*Hesperostipa spartea*)	3		
Needle and threadgrass (*Hesperostipa comata*)	2.7		
Hooker's oatgrass (*Avenula hookeri*)	1.8		
Sandgrass (*Calamovilfa longifolia*)	1.3		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1		
Sheep fescue (*Festuca saximontana*)	0.9		
Tickle hairgrass (*Agrostis scabra*)	0.5		
Major Forbs (11%)			
Fringed sage (*Artemisia frigida*)	1.7		
Blue-eyed grass (*Sisyrinchium montanum*)	1.5		
Smooth blue beardtongue (*Penstemon nitidus*)	1.3		
Prairie smoke (*Geum triflorum*)	1		
Hairy golden aster (*Heterotheca villosa*)	0.8		
Chickweed (*Cerastium arvense*)	0.8		
Common yarrow (*Achillea millefolium*)	0.7		
Harebell (*Campanula rotundifolia*)	0.5		
Cut-leaved anemone (*Anemone multifida*)	0.5		
Northern bedstraw (*Galium boreale*)	0.4		
Long-leaved bluets (*Houstonia longifolia*)	0.4		
Tufted white prairie aster (*Symphyotrichum ericoides*)	0.3		
Goat's beard (*Tragopogon dubius*)	0.3		
Dandelion (*Taraxacum officinale*)	0.3		
Pussy Toes (*Antennaria* spp.)	0.2		
Major Shrubs (0.3%)			
Rose (*Rosa* spp.)	0.3		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=2)	65 (60-69)	Relative Native (%)	72.5	**Forage Production (kg/ha)**
Clubmoss (n=2)	0.9 (0.7-1.2)	Native Richness	15	
Litter (n=2)	55 (43-67)	Relative Exotic (%)	27.5	
Bare soil (n=2)	0.1 (0.1-0.2)	Exotic Richness	2.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=0)	-	Pielou's Evenness Index	0.73	

SD7 – APAD

Poa pratensis – Artemisia – Hesperostipa comata

Kentucky Bluegrass – Fringed or Prairie Sage – Needle and Threadgrass

Sand

(n=13) This community is severely altered by increases in exotic species (~30%), mainly Kentucky bluegrass, and disturbance tolerant increaser forbs like sages. Some elements of this community were likely seeded long ago, in full or in part, with forage grasses. With additional western snowberry encroachment this community would transition to **SD17**.

Species Composition	% Biomass (n=3)	% Foliar Cover (n=10)	% Relative (n=13)
Major Graminoids (62.2%)			
Kentucky bluegrass (*Poa pratensis*)	32.1	18.8	26.9
Needle and threadgrass (*Hesperostipa comata*)	0.7	14	11.7
Junegrass (*Koeleria macrantha*)	0.3	2.6	2.6
Grassland sedge (*Carex* spp.)	2.5	2.3	2.5
Western porcupine-grass (*Hesperostipa curtiseta*)	4.3	1.7	2.3
Smooth brome (*Bromus inermis*)	4.4	1	1.9
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	1.9	1.6
Canada bluegrass (*Poa compressa*)	0	2.9	1.5
Western wheatgrass (*Pascopyrum smithii*)	0	1.1	1.4
Green needlegrass (*Nassella viridula*)	0.2	1	1.1
Crested wheatgrass (*Agropyron cristatum*)	3.3	0.6	1.1
Quackgrass (*Elymus repens*)	0	1.6	1
Fringed brome (*Bromus ciliatus*)	4.3	0	1
Plains rough fescue (*Festuca hallii*)	0	0.9	0.9
Northern wheatgrass (*Elymus lanceolatus*)	0	0.5	0.5
Prairie dropseed (*Sporobolus heterolepis*)	0	0.3	0.4
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.5	0	0.4
Sandgrass (*Calamovilfa longifolia*)	0	0.4	0.4
Major Forbs (30.5%)			
Fringed sage (*Artemisia frigida*)	28.4	4.1	10.3
Undifferentiated forbs	7.7	7.2	8.3
Prairie sage (*Artemisia ludoviciana*)	0	4.3	4.9
Curly-cup gumweed (*Grindelia squarrosa*)	2.8	0.9	1.4
Vetchling (*Vicia* spp.)	0	1.7	1.3
Northern bedstraw (*Galium boreale*)	0	0.8	1.1
Dandelion (*Taraxacum officinale*)	0	0.5	0.6
Silverleaf scurfpea (*Pediomelum argophyllum*)	0	0.8	0.6
Common yarrow (*Achillea millefolium*)	0.2	0.5	0.6
Major Shrubs (7.3%)			
Silver sage (*Artemisia cana*)	0	2.5	4.1
Western snowberry (*Symphoricarpos occidentalis*)	1.8	4.2	2.7
Rose (*Rosa* spp.)	1.5	0.2	0.4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	58	Relative Native (%)	66.6	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	9.6	
Litter (n=1)	70	Relative Exotic (%)	33.4	
Bare soil (n=0)	-	Exotic Richness	2	
Lichen (n=0)	-	Shannon's Diversity Index	1.9	
Moss (n=0)	-	Pielou's Evenness Index	0.79	

SD8 – APAD

Hesperostipa spartea – Bouteloua gracilis – Carex

Porcupine-grass – Blue Grama – Sedge

Sand

(n=29) This altered community is dominated by the decreaser porcupine-grass, which tends to be more abundant in the Assiniboine Delta Rangeland Ecoregion. Co-dominants are disturbance tolerant increaser graminoid species like blue grama and sedges, exotic species are minimal. Herbaceous cover is moderate and bare soil is minimal.

Species Composition	% Biomass (n=29)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (72.3%)			
Porcupine-grass (*Hesperostipa spartea*)	29.9		
Blue grama (*Bouteloua gracilis*)	14.5		
Grassland sedge (*Carex* spp.)	7.5		
Exotic bluegrass (*Poa* spp.)	4.6		
Junegrass (*Koeleria macrantha*)	3.4		
Needle and threadgrass (*Hesperostipa comata*)	2.1		
Sheep fescue (*Festuca saximontana*)	1.9		
Sandgrass (*Calamovilfa longifolia*)	1.5		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.4		
Western porcupine-grass (*Hesperostipa curtiseta*)	1.1		
Crested wheatgrass (*Agropyron cristatum*)	0.9		
Hooker's oatgrass (*Avenula hookeri*)	0.8		
Switchgrass (*Panicum virgatum*)	0.6		
Low sedge (*Carex duriuscula*)	0.6		
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	0.5		
Major Forbs (23.5%)			
Fringed sage (*Artemisia frigida*)	4.1		
Prairie smoke (*Geum triflorum*)	2.8		
Chickweed (*Cerastium arvense*)	2.2		
Northern bedstraw (*Galium boreale*)	1.8		
Common yarrow (*Achillea millefolium*)	1.4		
Prairie crocus (*Pulsatilla patens*)	1.4		
Sunflower (*Helianthus* spp.)	1.3		
Prairie sage (*Artemisia ludoviciana*)	1.3		
Purple prairie clover (*Dalea purpurea*)	0.8		
Cinquefoil (*Potentilla* spp.)	0.8		
Harebell (*Campanula rotundifolia*)	0.6		
Dotted blazing star (*Liatris punctata*)	0.6		
Major Shrubs (4.2%)			
Rose (*Rosa* spp.)	1.8		
Creeping juniper (*Juniperus horizontalis*)	1.2		
Western snowberry (*Symphoricarpos occidentalis*)	0.9		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=23)	40 (26-53)	Relative Native (%)	93.9	**Forage Production (kg/ha)**
Clubmoss (n=23)	11 (0-35)	Native Richness	17.2	
Litter (n=23)	35 (20-50)	Relative Exotic (%)	6.1	
Bare soil (n=23)	1 (0-11)	Exotic Richness	0.8	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=20)	0	Pielou's Evenness Index	0.75	

SD9 – APAD

Hesperostipa spartea – Carex – Bouteloua gracilis – Juniperus horizontalis

Porcupine-grass – Sedge – Blue Grama – Creeping Juniper

Sand

(n=11) Like **SD8**, this community likely has a history of alteration. It is still dominated by porcupine-grass, but there is relatively less, with similar graminoid increasers. However, there is increases in creeping juniper and additional grazing tolerant graminoids like sheep fescue and Wilcox's panic-grass Exotic species are minimal.

Species Composition	% Biomass (n=11)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (65.8%)			
Porcupine-grass (*Hesperostipa spartea*)	17.8		
Grassland sedge (*Carex* spp.)	13.7		
Blue grama (*Bouteloua gracilis*)	8.4		
Junegrass (*Koeleria macrantha*)	6.4		
Sheep fescue (*Festuca saximontana*)	5.4		
Sandgrass (*Calamovilfa longifolia*)	3.9		
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	2.3		
Hooker's oatgrass (*Avenula hookeri*)	1.7		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.5		
Needle and threadgrass (*Hesperostipa comata*)	1.2		
Kentucky bluegrass (*Poa pratensis*)	1		
Major Forbs (25.7%)			
Chickweed (*Cerastium arvense*)	4.6		
Fringed sage (*Artemisia frigida*)	2.4		
Sunflower (*Helianthus* spp.)	2.1		
Prairie smoke (*Geum triflorum*)	1.8		
Harebell (*Campanula rotundifolia*)	1.7		
Prairie sage (*Artemisia ludoviciana*)	1.7		
Prairie crocus (*Pulsatilla patens*)	1.5		
Goldenrod (*Solidago* spp.)	1.4		
Undifferentiated forbs	13		
Bastard toadflax (*Comandra umbellata*)	1.2		
Purple prairie clover (*Dalea purpurea*)	1.1		
Common yarrow (*Achillea millefolium*)	1.1		
Northern bedstraw (*Galium boreale*)	1		
Hairy golden aster (*Heterotheca villosa*)	0.9		
Little rose (*Chamaerhodos erecta*)	0.8		
Blue-eyed grass (*Sisyrinchium montanum*)	0..5		
Cinquefoil (*Potentilla* spp.)	0.4		
Major Shrubs (8.5%)			
Creeping juniper (*Juniperus horizontalis*)	6.7		
Rose (*Rosa* spp.)	1.9		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=3)	43 (38-50)	Relative Native (%)	98.7	**Forage Production (kg/ha)**
Clubmoss (n=3)	15 (3-23)	Native Richness	20.6	
Litter (n=3)	20 (17-24)	Relative Exotic (%)	1.3	
Bare soil (n=3)	0.3 (0-0.4)	Exotic Richness	0.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=2)	0	Pielou's Evenness Index	0.83	

SD10 – APAD

Juniperus horizontalis – Schizachyrium scoparium – Carex

Creeping Juniper – Little Bluestem - Sedge

Sand

(n=6) This significantly altered community has high creeping juniper cover associated with little bluestem. This community is likely altered from **SD9**, little bluestem can increase following disturbances like fire or overgrazing. Despite the high juniper cover, bare soil is excessive.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=6)	% Relative (n=6)
Major Graminoids			
Little bluestem (*Schizachyrium scoparium*)		12.4	16.9
Grassland sedge (*Carex* spp.)		6.1	8.3
Porcupine-grass (*Hesperostipa spartea*)		3.1	4.3
Sheep fescue (*Festuca saximontana*)		1	1.4
Junegrass (*Koeleria macrantha*)		0.6	0.8
Hooker's oatgrass (*Avenula hookeri*)		0.4	0.5
Plains rough fescue (*Festuca hallii*)		0.3	0.4
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)		0.2	0.3
Big bluestem (*Andropogon gerardii*)		0.2	0.2
Exotic bluegrass (*Poa* spp.)		0.4	0.5
Blue grama (*Bouteloua gracilis*)		0.2	0.2
Major Forbs			
Leafy spurge (*Euphorbia esula*)		1.1	1.5
Prairie smoke (*Geum triflorum*)		1	1.4
Showy sunflower (*Helianthus laetiflorus*)		1	1.4
Northern bedstraw (*Galium boreale*)		0.5	0.7
Missouri goldenrod (*Solidago missouriensis*)		0.5	0.7
Purple prairie clover (*Dalea purpurea*)		0.5	0.7
Bastard toadflax (*Comandra umbellata*)		0.5	0.6
Fringed sage (*Artemisia frigida*)		0.3	0.5
Hoary puccoon (*Lithospermum canescens*)		0.3	0.4
Long-fruited thimbleweed (*Anemone cylindrica*)		0.3	0.4
Prairie sage (*Artemisia ludoviciana*)		0.3	0.4
Hairy golden aster (*Heterotheca villosa*)		0.2	0.4
Plantain (*Plantago* spp.)		0.2	0.3
Pussy toes (*Antennaria* spp.)		0.2	0.3
Prairie crocus (*Pulsatilla patens*)		0.2	0.3
Blue-eyed grass (*Sisyrinchium montanum*)		0.1	0.2
Major Shrubs			
Creeping juniper (*Juniperus horizontalis*)		38.2	52.4
Rose (*Rosa* spp.)		0.3	0.5
Sand cherry (*Prunus pumila*)		0.3	0.4
Kinnikinnick (*Arctostaphylos uva-ursi*)		0.2	0.2

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	97.4	**Forage Production (kg/ha)**
Clubmoss (n=6)	0.2 (0-1)	Native Richness	42	
Litter (n=6)	18 (8-37)	Relative Exotic (%)	2.6	
Bare soil (n=6)	21 (9-35)	Exotic Richness	2.2	
Lichen (n=6)	0.3 (0-1)	Shannon's Diversity Index	1.8	
Moss (n=0)	-	Pielou's Evenness Index	0.47	

SD11 – APAD

Schizachyrium scoparium – Hesperostipa spartea – Festuca hallii

Little Bluestem – Porcupine-grass – Plains Rough Fescue

Sand

(n=1) An altered community dominated by little bluestem, potentially exhibiting high recovery of reference plant community decreasers porcupine-grass and plains rough fescue, overall graminoids have high (90%) representation. Little bluestem can increase following disturbances like fire or overgrazing. Exotic species are minimal. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (90.8%)			
Little bluestem (*Schizachyrium scoparium*)	35.8		
Porcupine-grass (*Hesperostipa spartea*)	24		
Plains rough fescue (*Festuca hallii*)	16		
Poverty oatgrass (*Danthonia spicata*)	7.6		
Grassland sedge (*Carex* spp.)	3.4		
Exotic Poa (*Poa* spp.)	3		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1		
Major Forbs (4.4%)			
Fringed sage (*Artemisia frigida*)	1.6		
Undifferentiated forbs	1.6		
Goldenrod (*Solidago* spp.)	1.2		
Major Shrubs (4.8%)			
Rose (*Rosa* spp.)	4.8		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	97	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	10	
Litter (n=0)	-	Relative Exotic (%)	3	
Bare soil (n=0)	-	Exotic Richness	1	
Lichen (n=0)	-	Shannon's Diversity Index	3.0	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

SD12 – APAD

Carex – Schizachyrium scoparium

Sedge – Little Bluestem

Sand

(n=12) In this significantly altered community, sedges are dominant with lower little bluestem and higher native forb cover relative to **SD10**. Juniper encroachment is far less severe. Bare soil is moderate to excessive.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=11)	% Relative (n=12)
Major Graminoids (49.3%)			
Grassland sedge (*Carex* spp.)	11.4	13.3	15.3
Little bluestem (*Schizachyrium scoparium*)	25	7.7	10.9
Porcupine-grass (*Hesperostipa spartea*)	9.2	2.3	3.9
Undifferentiated graminoids	0	4.3	3.6
Blue grama (*Bouteloua gracilis*)	0	2.4	2.4
Big bluestem (*Andropogon gerardii*)	0	1.7	2.2
Junegrass (*Koeleria macrantha*)	1.6	1.2	1.5
Needlegrass (*Hesperostipa* spp.)	0	0.9	1.2
Sheep fescue (*Festuca saximontana*)	0	1	1.1
Needle and threadgrass (*Hesperostipa comata*)	0	0.8	1
Kentucky bluegrass (*Poa pratensis*)	9.1	0.1	1
Major Forbs (36.8%)			
Pygmy flower (*Androsace septentrionalis*)	0	4.2	5.5
Northern bedstraw (*Galium boreale*)	2.3	3.3	4.2
Prairie sage (*Artemisia ludoviciana*)	0.7	2.1	1.9
Goldenrod (*Solidago* spp.)	0.2	1.4	1.7
Showy sunflower (*Helianthus laetiflorus*)	0	1.6	1.5
Bastard toadflax (*Comandra umbellata*)	1.8	1.1	1.5
Harebell (*Campanula rotundifolia*)	1.8	1	1.4
Purple prairie clover (*Dalea purpurea*)	0.5	1.3	1.3
Chickweed (*Cerastium arvense*)	0.5	0.9	1.2
Blue lettuce (*Mulgedium pulchellum*)	0	1	1.2
Tufted white prairie aster (*Symphyotrichum ericoides*)	0	1.2	1.1
Hoary puccoon (*Lithospermum canescens*)	1.2	0.8	1
Fringed sage (*Artemisia frigida*)	1.2	0.9	1
Major Trees and Shrubs (13.6%)			
Creeping juniper (*Juniperus horizontalis*)	0	3.3	3.5
Sand cherry (*Prunus pumila*)	0	2.2	2.8
Rose (*Rosa* spp.)	0	1.9	2.3
Western snowberry (*Symphoricarpos occidentalis*)	0	1.4	1.6
Prairie rose (*Rosa arkansana*)	0	2.7	1.4
Other (0.3%)			

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	62	Relative Native (%)	96.6	**Forage Production (kg/ha)**
Clubmoss (n=12)	0.2 (0-1)	Native Richness	35.7	
Litter (n=10)	41 (12-73)	Relative Exotic (%)	3.4	
Bare soil (n=10)	14 (1-55)	Exotic Richness	1.9	
Lichen (n=9)	1 (0-8)	Shannon's Diversity Index	2.5	
Moss (n=9)	0.2 (0-1)	Pielou's Evenness Index	0.72	

SD13 – APAD

Carex – Juniperus horizontalis* – Exotic *Poa / Artemisia frigida

Sedge – Creeping Juniper – Canada Bluegrass / Fringed Sage

Sand

(n=6) This severely altered community is dominated by sedge increasers and creeping juniper, but relative to **SD12**, it has higher amounts of exotic grasses and disturbance tolerant forbs like sage and prairie smoke. Bare soil is moderate to excessive. Litter cover is inadequate. Awned wheatgrass and silverweed cinquefoil could indicate that part of this community occurs on lower slope positions or in slight depressions that would be more mesic.

Species Composition	% Biomass (n=6)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (39.2%)			
Grassland sedge (*Carex* spp.)	15.3		
Exotic bluegrass (*Poa* spp.)	9.2		
Porcupine-grass (*Hesperostipa spartea*)	3.4		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	3.2		
Smooth brome (*Bromus inermis*)	1.4		
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)	1.1		
Junegrass (*Koeleria macrantha*)	1		
Sheep fescue (*Festuca saximontana*)	0.9		
Blue grama (*Bouteloua gracilis*)	0.9		
Saltgrass (*Distichlis spicata* var. *stricta*)	0.6		
Little bluestem (*Schizachyrium scoparium*)	0.6		
Plains rough fescue (*Festuca hallii*)	0.6		
Major Forbs (42.0%)			
Prairie smoke (*Geum triflorum*)	11.4		
Fringed sage (*Artemisia frigida*)	6.6		
Purple prairie clover (*Dalea purpurea*)	4.1		
Silverweed cinquefoil (*Argentina anserina*)	3.8		
Prairie sage (*Artemisia ludoviciana*)	1.9		
Canada goldenrod (*Solidago canadensis*)	1.4		
Common yarrow (*Achillea millefolium*)	1.1		
Hairy golden aster (*Heterotheca villosa*)	1		
Dandelion (*Taraxacum officinale*)	0.9		
Fleabane (*Erigeron* spp.)	0.8		
Bastard toadflax (*Comandra umbellata*)	0.7		
Prairie alumroot (*Heuchera richardsonii*)	0.7		
Pussy toes (*Antennaria* spp.)	0.6		
Tufted fleabane (*Erigeron caespitosus*)	0.6		
Major Trees and Shrubs (18.8%)			
Creeping juniper (*Juniperus horizontalis*)	13.5		
Rose (*Rosa* spp.)	3.5		
Western snowberry (*Symphoricarpos occidentalis*)	1.8		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=6)	61 (45-80)	Relative Native (%)	88	**Forage Production (kg/ha)**
Clubmoss (n=5)	2 (0-5)	Native Richness	16.7	953 kg/ha
Litter (n=6)	8 (3-20)	Relative Exotic (%)	12	
Bare soil (n=6)	10 (0-28)	Exotic Richness	1.6	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=6)	0	Pielou's Evenness Index	0.83	

SD14 – APAD

Exotic *Poa* – *Agropyron cristatum* – *Hesperostipa spartea*

Kentucky Bluegrass – Crested Wheatgrass – Porcupine-grass

Sand

(n=9) Community severely altered by exotic grasses which comprise ~35% of relative abundance. Sage abundance is also high and western snowberry abundance is notable. Soil exposure is low to moderate. This plant community was likely seeded long ago with a mixture containing crested wheatgrass but has changed to a mixed native and exotic community.

Species Composition	% Biomass (n=9)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (70.0%)			
Exotic bluegrass (*Poa* spp.)	17.3		
Crested wheatgrass (*Agropyron cristatum*)	10.4		
Porcupine-grass (*Hesperostipa spartea*)	9.9		
Smooth brome (*Bromus inermis*)	7.2		
Grassland sedge (*Carex* spp.)	4.6		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	4.3		
Blue grama (*Bouteloua gracilis*)	2.4		
Sandberg's bluegrass (*Poa secunda*)	2.2		
Fringed brome (*Bromus ciliatus*)	1.2		
Plains rough fescue (*Festuca hallii*)	1.1		
Sand dropseed (*Sporobolus cryptandrus*)	1		
Switchgrass (*Panicum virgatum*)	1		
Green Needlegrass (*Nassella viridula*)	1		
Needle and threadgrass (*Hesperostipa comata*)	0.9		
Junegrass (*Koeleria macrantha*)	0.6		
Major Forbs (20.2%)			
Fringed sage (*Artemisia frigida*)	3.7		
Prairie sage (*Artemisia ludoviciana*)	3		
Undifferentiated forbs	2.6		
Cinquefoil (*Potentilla* spp.)	1.8		
Goldenrod (*Solidago* spp.)	1.6		
Northern bedstraw (*Galium boreale*)	1.3		
Absinthe (*Artemisia absinthium*)	1.3		
Canada goldenrod (*Solidago canadensis*)	0.9		
Sunflower (*Helianthus* spp.)	0.8		
Fragrant bedstraw (*Galium triflorum*)	0.7		
Low everlasting (*Antennaria aprica*)	0.7		
Strawberry (*Fragaria virginiana*)	0.6		
Major Shrubs (9.8%)			
Western snowberry (*Symphoricarpos occidentalis*)	6.3		
Rose (*Rosa* spp.)	2.7		
Creeping juniper (*Juniperus horizontalis*)	0.6		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	51 (28-76)	Relative Native (%)	63.8	**Forage Production (kg/ha)**
Clubmoss (n=6)	7 (0-25)	Native Richness	11.3	
Litter (n=7)	55 (29-82)	Relative Exotic (%)	36.2	
Bare soil (n=6)	5 (0-16)	Exotic Richness	2.9	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=4)	0	Pielou's Evenness Index	0.82	

SD15 – APAD

Rosa – Euphorbia esula – Juniperus horizontalis – Schizachyrium scoparium / Carex

Rose – Leafy Spurge – Creeping Juniper – Little Bluestem / Carex

Sand

(n=11) This significantly altered community has some similarity to previous states (**SD12** to **SD13**), with its abundance of grassland sedges and little bluestem. However, rose encroachment and leafy spurge invasion make it unique. Relative cover of exotic species is ~20%, dominated by leafy spurge, and including small amounts of exotic grasses. Juniper is still abundant. Litter is also abundant while bare soil is low, on average.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=11)	% Relative (n=11)
Major Graminoids (41.5%)			
Little bluestem (*Schizachyrium scoparium*)		10.9	6.9
Grassland sedge (*Carex* spp.)		10.5	6.7
Porcupine-grass (*Hesperostipa spartea*)		9.8	6.2
Kentucky bluegrass (*Poa pratensis*)		6.4	4
Undifferentiated graminoids		3.5	2.2
Smooth brome (*Bromus inermis*)		3.3	2.1
Blue grama (*Bouteloua gracilis*)		2.8	1.8
Needle and threadgrass (*Hesperostipa comata*)		2.5	1.6
Big bluestem (*Andropogon gerardii*)		2.5	1.6
Junegrass (*Koeleria macrantha*)		1.6	1
Sandgrass (*Calamovilfa longifolia*)		1.4	0.9
Sheep fescue (*Festuca saximontana*)		1.2	0.8
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		1	0.6
Canary reedgrass (*Phalaris arundinacea*)		0.8	0.5
Major Forbs (26.8%)			
Leafy spurge (*Euphorbia esula*)		20	12.7
Prairie sage (*Artemisia ludoviciana*)		2.9	1.9
Sunflower (*Helianthus* spp.)		1.6	1
Tufted white prairie aster (*Symphyotrichum ericoides*)		1.3	0.8
Hoary puccoon (*Lithospermum canescens*)		1.2	0.8
Milkvetch (*Astragalus* spp.)		0.7	0.5
Northern bedstraw (*Galium boreale*)		0.6	0.4
Major Trees and Shrubs (31.5%)			
Rose (*Rosa* spp.)		29.4	18.6
Creeping juniper (*Juniperus horizontalis*)		12.7	8.1
Western snowberry (*Symphoricarpos occidentalis*)		8.7	5.5
Sand cherry (*Prunus pumila*)		4.3	2.7
White spruce (*Picea glauca*)		1.5	1
Other (0.2%)			
Horsetail (*Equisetum* spp.)		1.5	0.9

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=9)	59 (54-67)	Relative Native (%)	79.3	**Forage Production (kg/ha)**
Clubmoss (n=11)	2 (0-12)	Native Richness	29	
Litter (n=9)	76 (65-91)	Relative Exotic (%)	20.7	
Bare soil (n=9)	5 (0-22)	Exotic Richness	3.4	
Lichen (n=9)	5 (0-8)	Shannon's Diversity Index	2.2	
Moss (n=9)	3 (0-19)	Pielou's Evenness Index	0.67	

SD16– APAD

Euphorbia esula– Juniperus horizontalis – Poa pratensis

Leafy Spurge – Kentucky Bluegrass – Creeping Juniper

Sand

(n=6) This community is severely altered by the invasion of the noxious exotic weed leafy spurge and exotic Kentucky bluegrass. Decreaser abundance is very low and creeping juniper cover is high. Bare soil is low to moderate. This native plantcommunity is heavily invaded by leafy spurge.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=6)	% Relative (n=6)
Major Graminoids (44.2%)			
Kentucky bluegrass (*Poa pratensis*)		15.5	17
Grassland sedge (*Carex* spp.)		12.3	13.5
Little bluestem (*Schizachyrium scoparium*)		8.4	9.2
Needle and threadgrass (*Hesperostipa comata*)		1.9	2.1
Junegrass (*Koeleria macrantha*)		0.4	0.4
Hooker's oatgrass (*Avenula hookeri*)		0.3	0.4
Smooth brome (*Bromus inermis*)		0.3	0.3
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.1	0.1
Sheep fescue (*Festuca saximontana*)		0.1	0.1
Panic-grass (*Panicum* spp.)		0.1	0.1
Major Forbs (35.6%)			
Leafy spurge (*Euphorbia esula*)		31	33.8
Fringed sage (*Artemisia frigida*)		0.2	0.2
Plantain (*Plantago* spp.)		0.2	0.2
Pussy toes (*Antennaria* spp.)		0.2	0.2
Northern bedstraw (*Galium boreale*)		0.1	0.1
White prairie clover (*Dalea candida*)		0.1	0.1
Purple prairie clover (*Dalea purpurea*)		0.1	0.1
Long-fruited thimbleweed (*Anemone cylindrica*)		0.1	0.1
Major Shrubs (20.1%)			
Creeping juniper (*Juniperus horizontalis*)		18.9	20.7
Western snowberry (*Symphoricarpos occidentalis*)		0.5	0.5
Rose (*Rosa* spp.)		0.4	0.4
Other (0.1%)			
Smooth horsetail (*Equisetum laevigatum*)		0.1	0.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	47.1	**Forage Production (kg/ha)**
Clubmoss (n=6)	0	Native Richness	15	
Litter (n=6)	63 (28-97)	Relative Exotic (%)	52.9	
Bare soil (n=6)	5 (2-16)	Exotic Richness	3	
Lichen (n=6)	0	Shannon's Diversity Index	1.4	
Moss (n=0)	-	Pielou's Evenness Index	0.50	

SD17 – APAD

Hesperostipa comata – Symphoricarpos occidentalis – Poa pratensis / Koeleria macrantha

Needle and Threadgrass – Western Snowberry – Kentucky Bluegrass / Junegrass

Sand

(n=12) Altered community dominated by the increaser needle and threadgrass. It has significant woody encroachment from plants like western snowberry. Various exotic species are present with notable cover (~10%). Bare soil is becoming excessive.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=12)	% Relative (n=12)
Major Graminoids (60.5%)			
Needle and threadgrass (*Hesperostipa comata*)		25.3	22.5
Kentucky bluegrass (*Poa pratensis*)		7.9	7.1
Junegrass (*Koeleria macrantha*)		7.6	6.8
Grassland sedge (*Carex* spp.)		6.9	6.2
Blue grama (*Bouteloua gracilis*)		3.3	3
Hooker's oatgrass (*Avenula hookeri*)		2.6	2.4
Crested wheatgrass (*Agropyron cristatum*)		1.6	1.4
Green needlegrass (*Nassella viridula*)		1.5	1.3
Northern wheatgrass (*Elymus lanceolatus*)		1.4	1.2
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		1.3	1.2
Smooth brome (*Bromus inermis*)		1.1	1
Western porcupine-grass (*Hesperostipa curtiseta*)		0.9	0.8
Plains rough fescue (*Festuca hallii*)		0.8	0.7
Sandgrass (*Calamovilfa longifolia*)		0.6	0.6
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.6	0.5
Western wheatgrass (*Pascopyrum smithii*)		0.5	0.5
Plains muhly (*Muhlenbergia cuspidata*)		0.5	0.4
Porcupine-grass (*Hesperostipa spartea*)		0.5	0.4
Tickle hairgrass (*Agrostis scabra*)		0.3	0.2
Prairie dropseed (*Sporobolus heterolepis*)		0.3	0.2
Major Forbs (19.6%)			
Undifferentiated forbs		8.3	7.4
Fringed sage (*Artemisia frigida*)		7.5	6.7
Anemone (*Anemone* spp.)		1.6	1.4
Prairie sage (*Artemisia ludoviciana*)		0.9	0.8
Vetchling (*Vicia* spp.)		0.7	0.6
Silverleaf scurfpea (*Pediomelum argophyllum*)		0.7	0.6
Northern bedstraw (*Galium boreale*)		0.4	0.3
Dandelion (*Taraxacum officinale*)		0.3	0.3
Major Shrubs (19.9%)			
Western snowberry (*Symphoricarpos occidentalis*)		14	12.5
Rose (*Rosa* spp.)		5.2	4.7
Wolf willow (*Elaeagnus commutata*)		4.5	4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	89.6	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	14.3	
Litter (n=0)	-	Relative Exotic (%)	10.4	
Bare soil (n=3)	22 (13-32)	Exotic Richness	1.8	
Lichen (n=3)	6 (2-12)	Shannon's Diversity Index	2.2	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

SD18 – APAD

Hesperostipa spartea – Symphoricarpos occidentalis / Poa pratensis

Porcupine-grass – Western Snowberry – Kentucky Bluegrass

Sand

(n=17) This community is moderately altered, significantly encroached by western snowberry. The herbaceous community is dominated by the decreaser porcupine-grass, followed by Kentucky bluegrass. A diversity of decreaser grass species are present, but in reduced amounts. There are additional exotic grasses and forbs in small amounts. Bare soil is minimal.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=17)	% Relative (n=17)
Major Graminoids (59.8%)			
Porcupine-grass (*Hesperostipa spartea*)		32.7	27
Kentucky bluegrass (*Poa pratensis*)		23.4	19.3
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		6.3	5.2
Western wheatgrass (*Pascopyrum smithii*)		4.3	3.5
Grassland sedge (*Carex* spp.)		3.7	3
Blue grama (*Bouteloua gracilis*)		2.6	2.2
Green Needlegrass (*Nassella viridula*)		2.2	1.8
Needle and threadgrass (*Hesperostipa comata*)		1.7	1.4
Little bluestem (*Schizachyrium scoparium*)		0.9	0.7
Junegrass (*Koeleria macrantha*)		0.8	0.6
Mat muhly (*Muhlenbergia richarsonis*)		0.7	0.6
Smooth brome (*Bromus inermis*)		0.7	0.6
Prairie dropseed (*Sporobolus heterolepis*)		0.7	0.6
Plains rough fescue (*Festuca hallii*)		0.3	0.3
Plains reedgrass (*Calamagrostis montanensis*)		0.2	0.2
Saltgrass (*Distichlis spicata* var. *stricta*)		0.2	0.1
Intermediate wheatgrass (*Thinopyrum intermedium*)		0.2	0.1
Sandgrass (*Calamovilfa longifolia*)		0.1	0.1
Major Forbs (14.8%)			
Fringed sage (*Artemisia frigida*)		8.3	6.8
Undifferentiated forbs		8.1	6.7
Goat's beard (*Tragopogon dubius*)		0.4	0.3
Purple prairie clover (*Dalea purpurea*)		0.3	0.2
Canada thistle (*Cirsium arvense*)		0.3	0.2
Ground plum (*Astragalus crassicarpus*)		0.2	0.2
Dandelion (*Taraxacum officinale*)		0.2	0.1
American vetch (*Vicia americana*)		0.2	0.1
Major Shrubs (25.4%)			
Western snowberry (*Symphoricarpos occidentalis*)		23.4	19.3
Wolf willow (*Elaeagnus commutata*)		5.9	4.9
Rose (*Rosa* spp.)		2.3	1.9
Willow (*Salix* spp.)		0.5	0.4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	88.2	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	13	
Litter (n=0)	-	Relative Exotic (%)	11.8	
Bare soil (n=17)	1 (0-9)	Exotic Richness	2	
Lichen (n=17)	7 (0-27)	Shannon's Diversity Index	2.1	
Moss (n=0)	-	Pielou's Evenness Index	0.77	

SD19 – APAD

Symphoricarpos occidentalis – Poa pratensis – Elaeagnus commutata – Artemisia frigida

Western Snowberry – Kentucky Bluegrass – Wolf Willow – Fringed Sage

Sand

(n=7) This grassland has been severely altered by shrub encroachment and exotic grasses. The Herbaceous community is dominated by exotic grasses, Kentucky bluegrass and smooth brome. It was most likely seeded once, at least in part, to a mixture containing smooth brome and legumes. Exotic species comprise ~30% of the community.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=7)	% Relative (n=)
Major Graminoids (35.5%)			
Kentucky bluegrass (*Poa pratensis*)		25.1	16.5
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		12.8	8.4
Smooth brome (*Bromus inermis*)		12.3	8.1
Intermediate wheatgrass (*Thinopyrum intermedium*)		2.2	1.5
Junegrass (*Koeleria macrantha*)		0.3	0.2
Sandberg's bluegrass (*Poa secunda*)		0.2	0.1
Needle and threadgrass (*Hesperostipa comata*)		0.2	0.1
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.1	0.1
Sand dropseed (*Sporobolus cryptandrus*)		0.1	0
Grassland sedge (*Carex* spp.)		0.1	0
Major Forbs (22.4%)			
Fringed sage (*Artemisia frigida*)		16.9	11.1
Undifferentiated forbs		7	4.6
Common alfalfa (*Medicago sativa*)		3.5	2.3
Prairie sage (*Artemisia ludoviciana*)		1.6	1
Common yarrow (*Achillea millefolium*)		1.1	0.8
Canada thistle (*Cirsium arvense*)		1.1	0.7
Yellow sweet clover (*Melilotus officinalis*)		0.9	0.6
Silverleaf scurfpea (*Pediomelum argophyllum*)		0.6	0.4
Pussy toes (*Antennaria* spp.)		0.5	0.3
Prairie coneflower (*Ratibida columnifera*)		0.3	0.2
Vetch (*Vicia* spp.)		0.2	0.1
Dandelion (*Taraxacum officinale*)		0.1	0.1
Ground plum (*Astragalus crassicarpus*)		0.1	0
Goat's beard (*Tragopogon dubius*)		0.1	0
Major Shrubs (42.1%)			
Western snowberry (*Symphoricarpos occidentalis*)		34.3	22.6
Wolf willow (*Elaeagnus commutata*)		21.9	14.4
Rose (*Rosa* spp.)		2.9	1.9
Poplar (*Populus* spp.)		2.9	1.9
Chokecherry (*Prunus virginiana*)		1.7	1.1
Fireberry hawthorn (*Crataegus chrysocarpa*)		0.7	0.5

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	70.3	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	9.6	
Litter (n=0)	-	Relative Exotic (%)	29.7	
Bare soil (n=0)	-	Exotic Richness	3.3	
Lichen (n=0)	-	Shannon's Diversity Index	2.0	
Moss (n=0)	-	Pielou's Evenness Index	0.78	

SD20 – APAD

Symphoricarpos occidentalis – Elaeagnus commutata – Agropyron cristatum – Medicago sativa

Western Snowberry – Wolf Willow – Crested Wheatgrass - Alfalfa

Sand

(n=9) This severely altered grassland has become a shrubland. Relative to **SD19** there is greater encroachment of western snowberry and wolf willow. This community was likely once seeded with a mixture containing crested wheatgrass, smooth brome, intermediate wheatgrass, and alfalfa. With regards to forage value it is in better condition than **SD19** due to a greater abundance of palatable forages (crested wheatgrass, smooth brome, and alfalfa). Kentucky bluegrass abundance is minimal. Few native decreaser herbaceous species remain. Bare soil exposure is moderate.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=9)	% Relative (n=9)
Major Graminoids (35.4%)			
Crested wheatgrass (*Agropyron cristatum*)		25.5	13.8
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		12.7	6.9
Smooth brome (*Bromus inermis*)		7.8	4.2
Kentucky bluegrass (*Poa pratensis*)		5.5	3
Intermediate wheatgrass (*Thinopyrum intermedium*)		4.6	2.5
Green needlegrass (*Nassella viridula*)		4.4	2.4
Tall wheatgrass (*Thinopyrum ponticum*)		1.7	0.9
Needle and threadgrass (*Hesperostipa comata*)		0.7	0.4
Grassland sedge (*Carex* spp.)		0.2	0.1
Quackgrass (*Elymus repens*)		0.2	0.1
Prairie dropseed (*Sporobolus heterolepis*)		0.2	0.1
Western wheatgrass (*Pascopyrum smithii*)		0.1	0.1
Major Forbs (19.1%)			
Common alfalfa (*Medicago sativa*)		24	13
Fringed sage (*Artemisia frigida*)		6.6	3.6
Undifferentiated forbs		2.1	1.1
Canada thistle (*Cirsium arvense*)		1.4	0.8
Yellow sweet clover (*Melilotus officinalis*)		0.9	0.5
Prairie sage (*Artemisia ludoviciana*)		0.1	0
Vetch (*Vicia* spp.)		0.1	0
Major Shrubs (45.5%)			
Western snowberry (*Symphoricarpos occidentalis*)		35.7	19.4
Wolf willow (*Elaeagnus commutata*)		33.4	18.1
Alder (*Alnus* spp.)		6.7	3.6
Rose (*Rosa* spp.)		4	2.2
Poplar (*Populus* spp.)		2.8	1.5
Fireberry hawthorn (*Crataegus chrysocarpa*)		1.7	0.9
Chokecherry (*Prunus virginiana*)		1.1	0.6
Raspberry (*Rubus idaeus*)		0.2	0.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	61.3	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	6	
Litter (n=0)	-	Relative Exotic (%)	38.7	
Bare soil (n=1)	15	Exotic Richness	3.7	
Lichen (n=1)	1	Shannon's Diversity Index	1.8	
Moss (n=0)	-	Pielou's Evenness Index	0.81	

SD21M (Modified) – APAD

Poa pratensis – Artemisia ludoviciana / Galium boreale / Vicia americana

Kentucky Bluegrass – Prairie Sage / Northern Bedstraw / American Vetch

Sand

(n=4) This is a **Modified** grassland community, severely altered by invasion and/or seeding. Over half of its composition is made up of the exotic Kentucky bluegrass. Approximately 40% of the composition remains as native species, primarily as forbs. Many key decreaser grasses are apparently lost. It is unlikely that this will return to a healthy native plant community without significant intervention. Changes in grazing management could improve it to a higher quality mixed tame/native stand. Bare soil and clubmoss are minimal.

Species Composition	% Biomass (n=2)	% Foliar Cover (n=2)	% Relative (n=4)
Major Graminoids (63.1%)			
Kentucky bluegrass (*Poa pratensis*)	55.1	92	51.3
Grassland sedge (*Carex* spp.)	4.6	4.5	3.4
Smooth brome (*Bromus inermis*)	0.5	9	2.4
Tickle hairgrass (*Agrostis scabra*)	3.3	2	2.2
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	6.5	1.7
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.8	0	1.4
Major Forbs (31.7%)			
American vetch (*Vicia americana*)	0	14	3.7
Northern bedstraw (*Galium boreale*)	0	14	3.6
Prairie sage (*Artemisia ludoviciana*)	4.8	4.5	3.6
Fringed sage (*Artemisia frigida*)	5.2	0	2.6
Clover (*Trifolium* spp.)	4.6	0	2.3
Common yarrow (*Achillea millefolium*)	2.1	3	1.8
Star-flowered false Solomon's seal (*Maianthemum stellatum*)	0	5	1.2
Chickweed (*Cerastium arvense*)	0.8	2.5	1
Smooth blue aster (*Symphyotrichum laeve*)	0	4	1
Dandelion (*Taraxacum officinale*)	0.5	2.6	1
Cinquefoil (*Potentilla* spp.)	1.8	0	0.9
Smooth fleabane (*Erigeron glabellus*)	0	3	0.8
Pussy toes (*Antennaria* spp.)	1.5	0	0.8
Blue lettuce (*Mulgedium pulchellum*)	0	3	0.7
Common alfalfa (*Medicago sativa*)	0	3	0.7
Slender cinquefoil (*Potentilla gracilis*)	0	2.5	0.7
Veiny meadowrue (*Thalictrum venulosum*)	0	2.5	0.6
Blue-eyed grass (*Sisyrinchium montanum*)	0.1	2	0.6
Major Shrubs (4.9%)			
Willow (*Salix* spp.)	5.3	0	2.6
Western snowberry (*Symphoricarpos occidentalis*)	3.5	1.6	2.1
Other (0.3%)			

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	65	Relative Native (%)	42.7	**Forage Production (kg/ha)**
Clubmoss (n=3)	0	Native Richness	21.3	
Litter (n=3)	50 (40-57)	Relative Exotic (%)	57.3	
Bare soil (n=3)	3 (1-6)	Exotic Richness	2.8	
Lichen (n=0)	-	Shannon's Diversity Index	1.9	
Moss (n=3)	0	Pielou's Evenness Index	0.65	

SD22M (Modified) – APAD

Poa pratensis / Bromus inermis – Artemisia ludoviciana

Kentucky Bluegrass / Smooth Brome – Prairie Sage

Sand

(n=4) This is a **Modified** native grassland community now co-dominated by Kentucky bluegrass and smooth brome. Relative to **SD23M** there is greater native grass diversity and cover, beneficial grazing management is more likely to improve it to a stand dominated by high quality exotic forage. This community was likely once seeded to forages, although invasion is also possible.

Species Composition	% Biomass (n=2)	% Foliar Cover (n=2)	% Relative (n=4)
Major Graminoids (76.1%)			
Kentucky bluegrass (*Poa pratensis*)	38	11	28.2
Smooth brome (*Bromus inermis*)	12.8	28.6	27.8
Grassland sedge (*Carex* spp.)	7.9	1.8	3.6
Sandgrass (*Calamovilfa longifolia*)	0	3.9	2.8
Needle and threadgrass (*Hesperostipa comata*)	0	4.3	2.8
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	4.7	0	2.4
Northern wheatgrass (*Elymus lanceolatus*)	2.3	0.8	1.6
Saltgrass (*Distichlis spicata* var. *stricta*)	2.3	0	1.1
Dry-spike sedge (*Carex siccata*)	2.2	0	1.1
Junegrass (*Koeleria macrantha*)	2	0	1
Plains rough fescue (*Festuca hallii*)	0	1.3	0.8
Western wheatgrass (*Pascopyrum smithii*)	1.5	0	0.8
Mat muhly (*Muhlenbergia richardsonis*)	1.5	0	0.7
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)	0	0.8	0.7
Major Forbs (23.5%)			
Undifferentiated forbs	0	5	3.9
Prairie sage (*Artemisia ludoviciana*)	0.5	3.8	3.7
Aster (*Symphyotrichum* spp.)	5.5	0	2.8
Common yarrow (*Achillea millefolium*)	4.4	0	2.2
Low everlasting (*Antennaria aprica*)	3.5	0	1.8
Yellow sweet clover (*Melilotus officinalis*)	2	0	1
Goldenrod (*Solidago* spp.)	1.6	0	0.8
Prairie alumroot (*Heuchera richardsonii*)	1.4	0	0.7
Missouri milkvetch (*Astragalus missouriensis*)	1.3	0	0.6
Missouri goldenrod (*Solidago missouriensis*)	1.3	0	0.6
Chickweed (*Cerastium arvense*)	1	0	0.5
Milkweed (*Asclepias* spp.)	1	0	0.5
Dandelion (*Taraxacum officinale*)	0.8	0	0.4
Major Shrubs (1.4%)			
Western snowberry (*Symphoricarpos occidentalis*)	0.8	1.2	1.2

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	60	Relative Native (%)	42.6	**Forage Production (kg/ha)**
Clubmoss (n=1)	2	Native Richness	13.3	
Litter (n=1)	68	Relative Exotic (%)	57.4	
Bare soil (n=1)	4	Exotic Richness	2.8	
Lichen (n=0)	-	Shannon's Diversity Index	2.0	
Moss (n=0)	-	Pielou's Evenness Index	0.73	

SD23M (Modified) – APAD

Elymus repens – Agropyron cristatum – Poa pratensis

Quackgrass / Crested Wheatgrass – Kentucky Bluegrass

Sand

(n=5) This **Modified** grassland community was likely once seeded to a mixture containing crested wheatgrass, intermediate wheatgrass, quackgrass, alfalfa, and/or sweet clover. It is now dominated by quackgrass and crested wheatgrass. Kentucky bluegrass is present in low amounts. Disturbance-induced exotic weeds are present but make up a very small proportion. Relative exotic species abundance is very high at ~80%. Beneficial grazing management is more likely to sustain or improve the stand's pasture value, than to return it to a native grassland.

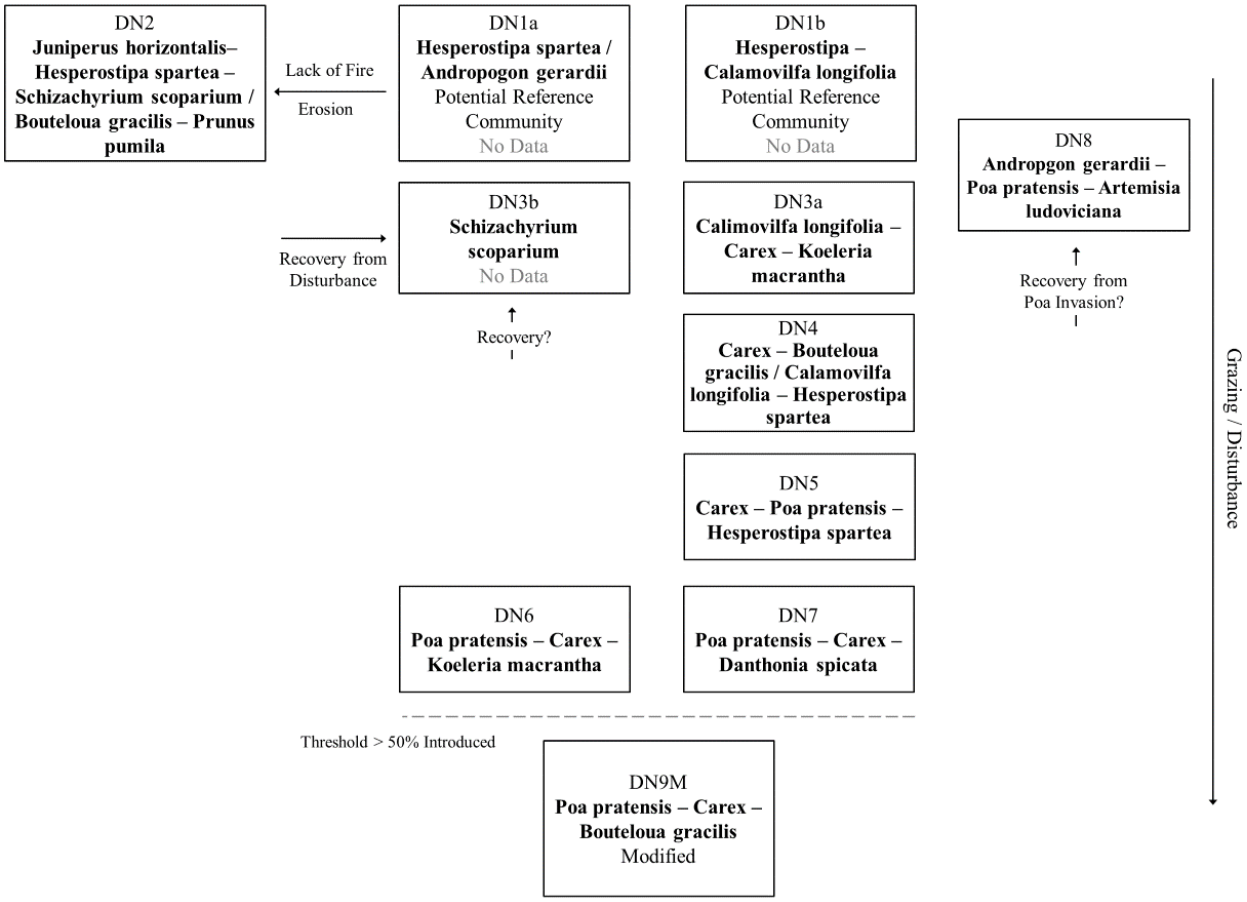
Species Composition	% Biomass (n=1)	% Foliar Cover (n=4)	% Relative (n=5)
Major Graminoids (76.3%)			
Quackgrass (*Elymus repens*)	0	46	36.8
Crested wheatgrass (*Agropyron cristatum*)	46.5	15.5	22
Kentucky bluegrass (*Poa pratensis*)	13	7.3	8.4
Porcupine-grass (*Hesperostipa spartea*)	20	0	4
Intermediate wheatgrass (*Thinopyrum intermedium*)	0	2.3	1.8
Smooth brome (*Bromus inermis*)	1.5	1.6	1.6
Grassland sedge (*Carex* spp.)	4	0	0.8
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.5	0.4	0.6
Sandgrass (*Calamovilfa longifolia*)	0	0.3	0.2
Junegrass (*Koeleria macrantha*)	0	0.1	0.1
Major Forbs (21.9%)			
Fringed sage (*Artemisia frigida*)	4	7	6.5
Common alfalfa (*Medicago sativa*)	0	5.6	4.3
Undifferentiated forbs	0	3.5	2.9
Yellow sweet clover (*Melilotus officinalis*)	3.5	1.3	1.7
Canada thistle (*Cirsium arvense*)	0	1.5	1.2
Prairie sage (*Artemisia ludoviciana*)	0	1.4	1.1
Perennial sowthistle (*Sonchus arvensis*)	0	1.1	0.9
Dandelion (*Taraxacum officinale*)	0	0.9	0.7
Goldenrod (*Solidago* spp.)	0	0.8	0.6
Northern bedstraw (*Galium boreale*)	2	0.3	0.6
Common yarrow (*Achillea millefolium*)	2.5	0	0.5
Blue lettuce (*Mulgedium pulchellum*)	0	0.5	0.4
Broomweed (*Gutierrezia sarothrae*)	1	0	0.2
Vetch (*Vicia* spp.)	0	0.1	0.1
Major Shrubs (1.8%)			
Prickly rose (*Rosa acicularis*)	0	1.7	1.3
Western snowberry (*Symphoricarpos occidentalis*)	0	0.6	0.5
Rose (*Rosa* spp.)	0.5	0	0.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	33	Relative Native (%)	20.6	**Forage Production (kg/ha)**
Clubmoss (n=1)	0	Native Richness	5	
Litter (n=1)	53	Relative Exotic (%)	79.4	
Bare soil (n=1)	0.4	Exotic Richness	4.2	
Lichen (n=0)	-	Shannon's Diversity Index	1.3	
Moss (n=1)	0	Pielou's Evenness Index	0.62	

Dunes (DN) – APAD

State-and-Transition Diagram

Grassland



Description of Dunes State and Transition Diagram

Dunes are a complex ecosite, with divergent plant communities emerging from dune topography and stability. Communities often resemble plant communities described for the sand ecosite, however dunes will respond differently to grazing and other disturbances due to their sensitivity to erode when vegetation and soil cover are compromised. Reference plant communities are unstable juniper-dominated, unstable sandgrass-dominated, or stable porcupine grass/big bluestem. Fewer juniper-dominated communities, and communities with high levels of bare soil emerged from the data than what we expected for dunes. Relative to sand higher soil exposure is likely, it is important to consider whether soil exposure is natural or accelerated by management. More data collection is required to describe the reference plant communities for this ecosite. It is possible that some of the severely altered plant communities were formerly cultivated and seeded to forages. The seeded communities would have degraded first, or failed in establishment, before going back to native species from the seedbank or adjacent seed sources.

Image 5. Example of a dunes ecosite in the Rutledg Sandhills, where sand deposits are shaped into hills and ridges by wind. Photo credit Mae Elsinger.

DN1a – APAD
Hesperostipa spartea / Andropogon gerardii
Porcupine-grass / Big Bluestem
Dunes

NO DATA

(n=0) This later seral **potential reference plant community**, established on somewhat stabilized dune sand, is expected to consist predominantly of tall, decreaser grasses such as porcupine-grass (*Hesperostipa spartea*) and warm season sand reedgrass (*Calamovilfa longifolia*), with big bluestem (*Andropogon gerardii*) in patches in depressions or the moister lees of slopes. Sand bluestem (*Andropogon hallii*) is unique to, and frequently encountered in some large dune communities in the Aspen Parkland (e.g. Lauder Sandhills Wildlife Management Area) and Assiniboine Delta (e.g. Spruce Woods Provincial Park), but it is absent in our current datasets. Other tall decreaser species like sideoats grama (*Bouteloua curtipendula*) or indiangrass (*Sorgastrum nutans*) could co-occur. In lesser proportions, space between tufted decreasers could be occupied by midgrasses like sandgrass (*Calamovilfa longifolia*), little bluestem (*Schizachyrium scoparium*), or dropseed species (*Sporobolus* spp.). Low cover (<5%) from prostrate and erect shrubs is expected in this stabilized community. Bare soil may exist, but in low to moderate amounts as the soil surface should be stabilized by a biological crust and covered with litter from productive grasses. If shrub cover is greater than late seral tall grass decreasers refer to **DN2**. A reference plant community dominated by plains rough fescue (*Festuca hallii*) potentially exists, as demonstrated on coarse textured ecosites in Alberta and Saskatchewan. Reference plant communities like **SD1a** and **SD1b** may be applicable to dunes.

Image 6. Dunes stabilized by Sand Bluestem (*Andropogon hallii*) (glaucous, blue-grey leaves) at the Lauder Sandhills Wildlife Management Area. Photo credit Mae Elsinger.

DN1b – APAD

Hesperostipa spartea* / *H. curtiseta* – *Calamovilfa longifolia
Porcupine-grass / Western Porcupine-grass – Sandgrass
Dunes

NO DATA

(n=0) This is a potential **reference plant community** that could occur on xeric (well drained) or less stable dunes. Sandgrass is considered a marginal decreaser in Manitoba and is present in reference plant communities described for Parkland and Mixedgrass prairies in Alberta (Kupsch et al. 2013) and Saskatchewan (Thorpe 2014). Comparable communities in Saskatchewan are dominated by needle-and-threadgrass (*Hesperostipa comata*) but either porcupine-grass species are expected to dominate or co-dominate in Manitoba. Aspen Parkland dunes could also include high proportions of plains rough fescue (*Festuca hallii*) (Kupsch et al. 2013) resembling **SD1a**. More data collection is necessary to clarify the content of this type of community. It is possible for this community to include an understory of creeping juniper (*Juniperus horizontalis*), particularly on less stable dunes.

Image 7. Dunes slope stabilized by a combination of porcupine grasses (*Hesperostipa* spp) and sand grass (*Calamovilfa longifoli*a) in Spruce Woods Provincial Park.

DN2 – APAD

Juniperus horizontalis – Hesperostipa spartea – Schizachyrium scoparium / Bouteloua gracilis – Prunus pumila

Creeping Juniper – Porcupine-grass – Little Bluestem / Blue Grama – Sand Cherry

Dunes

(n=2) An altered from **DN1a** (possibly **DN1b**), now in a mid-stage of recovery towards a new later seral state containing moderate amounts of creeping juniper. Past disturbance has reduced the cover of tall grasses, promoting greater cover of native grass increaser plants, reducing litter cover, and increasing bare soil exposure. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=2)	% Relative (n=2)
Major Graminoids (40.7%)			
Porcupine-grass (*Hesperostipa spartea*)		12.3	15.3
Little bluestem (*Schizachyrium scoparium*)		6.6	8.2
Blue grama (*Bouteloua gracilis*)		6.5	8
Junegrass (*Koeleria macrantha*)		3.2	4
Sedge (*Carex* spp.)		3	3.7
Wilcox's panic-grass (*Dichanthelium wilcoxianum*)		0.3	0.4
Sheep fescue (*Festuca saximontana*)		0.2	0.3
Major Forbs (28.5%)			
Showy sunflower (*Helianthus laetiflorus*)		3.1	3.9
Chickweed (*Cerastium arvense*)		2.2	2.7
Hoary puccoon (*Lithospermum canescens*)		2.1	2.6
Fleabane (*Erigeron* spp.)		2	2.5
Harebell (*Campanula rotundifolia*)		1.7	2.1
Bastard toadflax (*Comandra umbellata*)		1.2	1.4
Purple prairie clover (*Dalea purpurea*)		1.1	1.4
Northern bedstraw (*Galium boreale*)		1	1.3
Rockcress (*Arabis / Boechera* spp.)		0.9	1.1
Prairie sage (*Artemisia ludoviciana*)		0.7	1
Common yarrow (*Achillea millefolium*)		0.6	0.7
Goldenrod (*Solidago* spp.)		0.5	0.7
Prairie crocus (*Pulsatilla patens*)		0.5	0.6
False dandelion (*Agoseris glauca*)		0.5	0.6
Gaillardia (*Gaillardia aristata*)		0.4	0.5
Major Shrubs (30.7%)			
Juniper (*Juniperus horizontalis*)		15.6	19.4
Sand cherry (*Prunus pumila*)		3.8	4.7
Kinnikinnick (*Arctostaphylos uva-ursi*)		3.6	4.5
Rose (*Rosa* spp.)		2	2.4
Other (0.1%)			
Scouringrush horsetail (*Equisetum hyemale*)		0.1	0.1

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	99.7	**Forage Production (kg/ha)**
Clubmoss (n=2)	0	Native Richness	43.5	
Litter (n=2)	23 (19-27)	Relative Exotic (%)	0.3	
Bare soil (n=2)	17 (2-33)	Exotic Richness	1	
Lichen (n=2)	1 (0-2)	Shannon's Diversity Index	2.8	
Moss (n=2)	0 (0-0.2)	Pielou's Evenness Index	0.74	

DN3a – APAD

Calamovilfa longifolia – Carex – Hesperostipa curtiseta

Sandgrass – Sedge – Western Porcupine-grass

Dunes

(n=5) This dunes community appears to be moderately altered from the stable reference plant community and is now dominated by sandgrass and sedges. There have been strong decreases in plants that are dominant in the reference plant community like porcupine-grasses and big bluestem. Exotic grasses exist in small amounts. This community could occur on less stable dunes, but data for soil exposure is insufficient to confirm the level of site stability.

Species Composition	% Biomass (n=5)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (68.2%)			
Sand grass (*Calamovilfa longifolia*)	17.2		
Sedge (*Carex* spp.)	12		
Western porcupine-grass (*Hesperostipa curtiseta*)	8.3		
Junegrass (*Koeleria macrantha*)	6.6		
Porcupine-grass (*Hesperostipa spartea*)	6.4		
Exotic Poa (*Poa* spp.)	4.4		
Sheep fescue (*Festuca saximontana*)	3.8		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	3.2		
Blue grama (*Bouteloua gracilis*)	1.6		
Hooker's oatgrass (*Avenula hookeri*)	1.6		
Crested wheatgrass (*Agropyron cristatum*)	1.6		
Plains rough fescue (*Festuca hallii*)	0.9		
Major Forbs (27.4%)			
Fringed sage (*Artemisia frigida*)	4.4		
Prairie crocus (*Pulsatilla patens*)	2.6		
Chickweed (*Cerastium arvense*)	2.4		
Hairy golden aster (*Heterotheca villosa*)	2.4		
Goldenrod (*Solidago* spp.)	2		
Purple prairie clover (*Dalea purpurea*)	1.9		
Little rose (*Chamaerhodos erecta*)	1.8		
Common yarrow (*Achillea millefolium*)	1.6		
Bastard toadflax (*Comandra umbellata*)	1.3		
Showy sunflower (*Helianthus laetiflorus*)	1.3		
Blue-eyed grass (*Sisyrinchium montanum*)	0.9		
Northern bedstraw (*Galium boreale*)	0.8		
Major Shrubs (2.2%)			
Rose (*Rosa* spp.)	1.2		
Other (2.2%)			
Horsetail (*Equisetum* spp.)	2.2		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	50	Relative Native (%)	94.0	**Forage Production (kg/ha)**
Clubmoss (n=1)	20	Native Richness	18.6	
Litter (n=1)	32	Relative Exotic (%)	6.0	
Bare soil (n=1)	2	Exotic Richness	1.2	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=0)	-	Pielou's Evenness Index	0.84	

DN3b – APAD

Schizachyrium scoparium

Little Bluestem

Dunes

NO DATA

(n=0) There is potential for an altered plant community to occur on dunes dominated by little bluestem (*Schizachyrium scoparium*) which likely rebounded after a disturbance history of heavy grazing pressure, fire or other intense disturbances. This plant community was observed frequently in the Assiniboine Delta and occasionally elsewhere in the Aspen Parkland. Currently, **SD11** may be the best representation of this community.

Image 8. Litte bluestem (*Schizachyrium scoparium*) dominated grasslands in Spruce Woods Provincial Park.

DN4 – APAD

Carex – Bouteloua gracilis / Calamovilfa longifolia – Hesperostipa spartea

Sedge – Blue Grama / Sandgrass – Porcupine-grass

Dunes

(n=9) This community is significantly altered, at an earlier seral stage compared to **DN3a**, with increases in sedge and blue grama. Spear-grasses and sandgrass are reduced, and there is some invasion by exotic bluegrasses and smooth brome. Herbaceous cover and litter cover are low to moderate. Bare soil is low and a biological crust is intact.

Species Composition	% Biomass (n=9)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (76.3%)			
Sedge (*Carex* spp.)	14.5		
Blue grama (*Bouteloua gracilis*)	11.6		
Sand grass (*Calamovilfa longifolia*)	11.2		
Porcupine-grass (*Hesperostipa spartea*)	8.8		
Junegrass (*Koeleria macrantha*)	7.6		
Kentucky bluegrass (*Poa pratensis*)	7.2		
Needle and threadgrass (*Hesperostipa comata*)	4.1		
Smooth brome (*Bromus inermis*)	3.9		
Crested wheatgrass (*Agropyron cristatum*)	2.7		
Exotic bluegrass (*Poa* spp.)	1.8		
Western porcupine-grass (*Hesperostipa curtiseta*)	1.6		
Sand dropseed (*Sporobolus cryptandrus*)	0.6		
Major Forbs (18.8%)			
Fringed sage (*Artemisia frigida*)	4.9		
Northern bedstraw (*Galium boreale*)	2.7		
Chickweed (*Cerastium arvense*)	2.3		
Common yarrow (*Achillea millefolium*)	1.8		
Silverweed cinquefoil (*Argentina anserina*)	0.9		
Strawberry (*Fragaria virginiana*)	0.8		
Broomweed (*Gutierrezia sarothrae*)	0.7		
Prairie sage (*Artemisia ludoviciana*)	0.7		
Gaillardia (*Gaillardia aristata*)	0.6		
Prairie smoke (*Geum triflorum*)	0.6		
Harebell (*Campanula rotundifolia*)	0.6		
Purple prairie clover (*Dalea purpurea*)	0.3		
White prairie clover (*Dalea candida*)	0.2		
Major Shrubs (4.2%)			
Rose (*Rosa* spp.)	3.6		
Creeping juniper (*Juniperus horizontalis*)	0.6		
Other (0.7%)			
Scouringrush horsetail (*Equisetum hyemale*)	0.6		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	41 (29-57)	Relative Native (%)	84.4	**Forage Production (kg/ha)**
Clubmoss (n=7)	10 (0-23)	Native Richness	13.3	
Litter (n=7)	31 (21-48)	Relative Exotic (%)	15.6	
Bare soil (n=7)	7.3 (0-21)	Exotic Richness	1.6	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=5)	8 (0-38)	Pielou's Evenness Index	0.82	

DN5 – APAD

Carex – Poa pratensis – Hesperostipa spartea

Sedge – Kentucky Bluegrass – Porcupine-grass

Dunes

(n=12) This significantly altered dunes grassland is dominated by sedge increasers and Kentucky bluegrass. Decreasers reference plant community (**DN1a**) are somewhat abundant, with porcupine-grass, big bluestem, and sandgrass considerably reduced from their potential. Bare soil and clubmoss cover are lower than expected for a significantly disturbed community on dunes.

Species Composition	% Biomass (n=12)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (66.0%)			
Sedge (*Carex* spp.)	19		
Kentucky bluegrass (*Poa pratensis*)	15		
Porcupine-grass (*Hesperostipa spartea*)	5.9		
Sandgrass (*Calamovilfa longifolia*)	3.3		
Blue grama (*Bouteloua gracilis*)	3.2		
Big bluestem (*Andropogon gerardii*)	2.9		
Junegrass (*Koeleria macrantha*)	2.7		
Needle and threadgrass (*Hesperostipa comata*)	2.5		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.5		
Western porcupine-grass (*Hesperostipa curtiseta*)	1.7		
Little bluestem (*Schizachyrium scoparium*)	1.5		
Crested wheatgrass (*Agropyron cristatum*)	1.3		
Starved witch-grass (*Dichanthelium depauperatum*)	1		
Poverty oatgrass (*Danthonia spicata*)	0.9		
Plains rough fescue (*Festuca hallii*)	0.7		
Major Forbs (31.4%)			
Prairie smoke (*Geum triflorum*)	8.3		
Prairie sage (*Artemisia ludoviciana*)	3.4		
Purple prairie clover (*Dalea purpurea*)	2.6		
Common yarrow (*Achillea millefolium*)	1.8		
Showy sunflower (*Helianthus laetiflorus*)	1.5		
Tufted white prairie aster (*Symphyotrichum ericoides*)	1.5		
Hoary puccoon (*Lithospermum canescens*)	1.3		
Chickweed (*Cerastium arvense*)	1		
Pussy toes (*Antennaria* spp.)	1		
Goldenrod (*Solidago* spp.)	0.9		
Bastard toadflax (*Comandra umbellata*)	0.9		
Major Shrubs (0.6%)			
Poison ivy (*Toxicodendron radicans*)	0.6		
Other (2.0%)			
Scouringrush horsetail (*Equisetum hyemale*)	2		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=12)	57 (43-73)	Relative Native (%)	83.3	**Forage Production (kg/ha)**
Clubmoss (n=12)	7 (0-17)	Native Richness	23.3	
Litter (n=12)	35 (23-48)	Relative Exotic (%)	16.7	
Bare soil (n=12)	2 (0-7)	Exotic Richness	1.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.6	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

DN6 – APAD

Poa pratensis – Carex – Koeleria macrantha

Kentucky Bluegrass – Sedge – Junegrass

Dunes

(n=18) This severely altered grassland now contains at least 30% exotic species, contributed primarily from Kentucky bluegrass. Grazing tolerant native grasses and forbs make up most of the balance. The decreasers represented in later seral communities are present, but in low abundance, though there is potential for improvement to a healthy stand. Bare soil exposure is low.

Species Composition	% Biomass (n=18)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (72.7%)			
Kentucky bluegrass (*Poa pratensis*)	26.5		
Grassland sedge (*Carex* spp.)	14.5		
Junegrass (*Koeleria macrantha*)	5.7		
Blue grama (*Bouteloua gracilis*)	4.9		
Sandgrass (*Calamovilfa longifolia*)	3.8		
Porcupine-grass (*Hesperostipa spartea*)	3.6		
Little bluestem (*Schizachyrium scoparium*)	2.8		
Needle and threadgrass (*Hesperostipa comata*)	1.9		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.3		
Smooth brome (*Bromus inermis*)	1.2		
Western porcupine-grass (*Hesperostipa curtiseta*)	1.1		
Quackgrass (*Elymus repens*)	1.1		
Starved witch-grass (*Dichanthelium depauperatum*)	1		
Sand dropseed (*Sporobolus cryptandrus*)	0.9		
Poverty oatgrass (*Danthonia spicata*)	0.8		
Big bluestem (*Andropogon gerardii*)	0.6		
Major Forbs (22.6%)			
Prairie smoke (*Geum triflorum*)	4.9		
Prairie sage (*Artemisia ludoviciana*)	4		
Common yarrow (*Achillea millefolium*)	2.7		
Chickweed (*Cerastium arvense*)	1		
Fringed sage (*Artemisia frigida*)	0.8		
Smooth fleabane (*Erigeron glabellus*)	0.8		
Purple prairie clover (*Dalea purpurea*)	0.8		
Showy sunflower (*Helianthus laetiflorus*)	0.7		
Missouri goldenrod (*Solidago missouriensis*)	0.7		
Hoary puccoon (*Lithospermum canescens*)	0.7		
Major Shrubs (2.9%)			
Poison ivy (*Toxicodendron radicans*)	2.9		
Other (1.8%)			
Scouringrush horsetail (*Equisetum hyemale*)	1.8		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=18)	50 (40-64)	Relative Native (%)	71.1	**Forage Production (kg/ha)**
Clubmoss (n=18)	12 (0-30)	Native Richness	18.9	
Litter (n=18)	30 (18-45)	Relative Exotic (%)	28.9	
Bare soil (n=18)	4 (0-15)	Exotic Richness	1.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.3	
Moss (n=0)	-	Pielou's Evenness Index	0.77	

DN7 – APAD

Poa pratensis – Carex – Danthonia spicata

Kentucky Bluegrass – Sedge – Poverty Oatgrass

Dunes

(n=3) This severely altered grassland now contains at least 30% exotic species, contributed primarily from Kentucky bluegrass. Similar to **DN6**, grazing tolerant native grasses remain, especially with a strong increase in poverty oatgrass which likes dry, overgrazed conditions. The decreasers represented in the later seral communities are absent, leaving very little potential for improvement to a healthy native stand in the reasonable future. Such a total absence may be due to cultivation and abandonment, combined with a xeric soil. Bare soil exposure and clubmoss cover are low.

Species Composition	% Biomass (n=3)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (70.7%)			
Kentucky bluegrass (*Poa pratensis*)	26.8		
Grassland sedge (*Carex* spp.)	18		
Poverty oatgrass (*Danthonia spicata*)	11.8		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	4.3		
Quackgrass (*Elymus repens*)	2.2		
Junegrass (*Koeleria macrantha*)	2		
Needle and threadgrass (*Hesperostipa comata*)	1.7		
Sand dropseed (*Sporobolus cryptandrus*)	1.2		
Blue grama (*Bouteloua gracilis*)	0.8		
Starved witch-grass (*Dichanthelium depauperatum*)	0.8		
Sheep fescue (*Festuca saximontana*)	0.7		
Major Forbs (28.8%)			
Prairie sage (*Artemisia ludoviciana*)	5.3		
Tufted white prairie aster (*Symphyotrichum ericoides*)	3.5		
Common yarrow (*Achillea millefolium*)	2.2		
Smooth fleabane (*Erigeron glabellus*)	2		
Pussy toes (*Antennaria* spp.)	1.3		
Perennial ragweed (*Ambrosia psilostachya*)	1.3		
Purple prairie clover (*Dalea purpurea*)	1.2		
Hoary puccoon (*Lithospermum canescens*)	1.2		
Prairie smoke (*Geum triflorum*)	1		
Locoweed (*Oxytropis* spp.)	1		
Showy sunflower (*Helianthus laetiflorus*)	0.8		
Narrow-leaved puccoon (*Lithospermum incisum*)	0.8		
Fleabane (*Erigeron* spp.)	0.8		
Hairy golden aster (*Heterotheca villosa*)	0.7		
Velvety goldenrod (*Solidago mollis*)	0.7		
Willow aster (*Symphyotrichum lanceolatum* var. *hesperium*)	0.7		
Other (0.5%)			
Scouringrush horsetail (*Equisetum hyemale*)	0.5		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=3)	55 (45-60)	Relative Native (%)	71	**Forage Production (kg/ha)**
Clubmoss (n=3)	5 (0-13)	Native Richness	21.7	
Litter (n=3)	38 (34-45)	Relative Exotic (%)	29	
Bare soil (n=3)	1 (0-2)	Exotic Richness	1.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.4	
Moss (n=0)	-	Pielou's Evenness Index	0.76	

DN8 – APAD

Andropogon gerardii – Poa pratensis – Artemisia ludoviciana

Big Bluestem – Kentucky Bluegrass – Prairie Sage

Dunes

(n=2) This community is at a mid-seral stage, likely recovering from significant to severe alteration by overgrazing combined with invasion or partial seeding with exotic forages. It is now dominated by big bluestem, a decreaser from the potential reference plant community (**DN1a**). About 20% of the composition is exotic cover from Kentucky bluegrass and smooth brome. Increaser grasses and forbs remain somewhat abundant. The other key decreasers from later seral communities are absent, possibly meaning that this community may succeed towards a new stable state. Herbaceous cover is likely lower than expected for a big bluestem dominated community. Bare soil exposure is low.

Species Composition	% Biomass (n=2)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (77.0%)			
Big bluestem (*Andropogon gerardii*)	43.5		
Kentucky bluegrass (*Poa pratensis*)	13.5		
Smooth brome (*Bromus inermis*)	5.5		
Grassland sedge (*Carex* spp.)	3.8		
Little bluestem (*Schizachyrium scoparium*)	3.8		
Poverty oatgrass (*Danthonia spicata*)	1.8		
Crested wheatgrass (*Agropyron cristatum*)	1.5		
Needle and threadgrass (*Hesperostipa comata*)	1		
Sand dropseed (*Sporobolus cryptandrus*)	1		
Junegrass (*Koeleria macrantha*)	0.8		
Intermediate wheatgrass (*Thinopyrum intermedium*)	0.8		
Tickle hairgrass (*Agrostis scabra*)	0.3		
Major Forbs (19.0%)			
Prairie sage (*Artemisia ludoviciana*)	7.3		
Smooth fleabane (*Erigeron glabellus*)	2.3		
Purple prairie clover (*Dalea purpurea*)	1.5		
Goldenrod (*Solidago* spp.)	1		
Common yarrow (*Achillea millefolium*)	0.8		
Hoary puccoon (*Lithospermum canescens*)	0.8		
Fringed sage (*Artemisia frigida*)	0.8		
White prairie clover (*Dalea candida*)	0.8		
Tufted white prairie aster (*Symphyotrichum ericoides*)	0.5		
Pussy toes (*Antennaria* spp.)	0.5		
Perennial ragweed (*Ambrosia psilostachya*)	0.5		
Cut-leaved anemone (*Anemone multifida*)	0.5		
Bee balm (*Monarda fistulosa*)	0.5		
Virginia groundcherry (*Physalis virginiana*)	0.3		
Other (4.0%)			
Scouringrush horsetail (*Equisetum hyemale*)	4		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=2)	49 (40-58)	Relative Native (%)	78.7	**Forage Production (kg/ha)**
Clubmoss (n=2)	0.2 (0-0.3)	Native Richness	18	
Litter (n=2)	50 (43-58)	Relative Exotic (%)	21.3	
Bare soil (n=2)	1 (0-2)	Exotic Richness	3	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=0)	-	Pielou's Evenness Index	0.68	

DN9M (Modified) – APAD

Poa pratensis – Bromus inermis – Carex

Kentucky Bluegrass – Smooth brome – Sedge

Dunes

(n=5) This is a **Modified** native grassland community dominated by Kentucky bluegrass, comprising at least 50% of community biomass. About 60% of the community is exotic. Increaser grasses and forbs make up the majority of remaining native abundance. A number of decreasers are present, leading to possibility of improvement with targeted grazing practices. Exclusion from grazing will likely allow Kentucky bluegrass to remain most abundant, or for smooth brome to increase. Diversity and evenness are relatively lower than dunes grasslands with relatively more native cover. Bare soil is minimal.

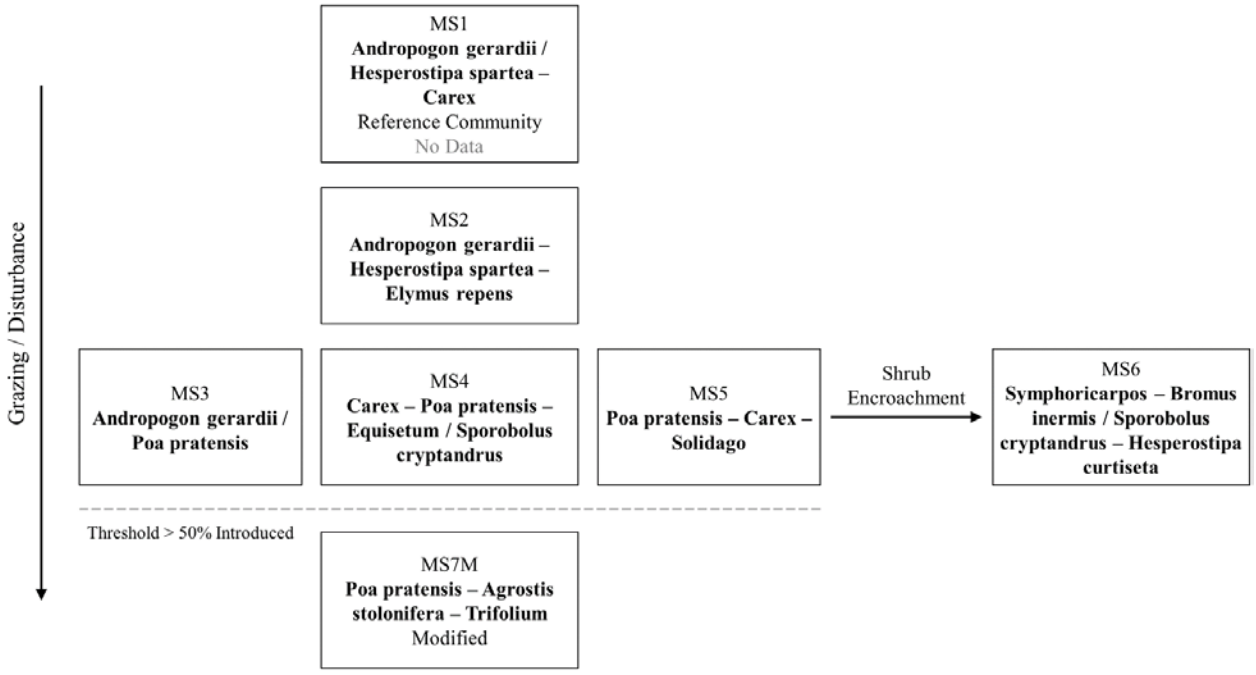
Species Composition	% Biomass (n=5)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (81.4%)			
Kentucky bluegrass (*Poa pratensis*)	48.8		
Smooth brome (*Bromus inermis*)	8.4		
Grassland sedge (*Carex* spp.)	7.5		
Blue grama (*Bouteloua gracilis*)	4.2		
Sandgrass (*Calamovilfa longifolia*)	1.9		
Junegrass (*Koeleria macrantha*)	1.8		
Poverty oatgrass (*Danthonia spicata*)	1.7		
Porcupine-grass (*Hesperostipa spartea*)	1.7		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.6		
Sheep fescue (*Festuca saximontana*)	1.1		
Starved witch-grass (*Dichanthelium depauperatum*)	0.7		
Tickle hairgrass (*Agrostis scabra*)	0.4		
Plains rough fescue (*Festuca hallii*)	0.4		
Major Forbs (13.0%)			
Common yarrow (*Achillea millefolium*)	2		
Prairie smoke (*Geum triflorum*)	1.4		
Prairie sage (*Artemisia ludoviciana*)	1.2		
Tufted white prairie aster (*Symphyotrichum ericoides*)	0.9		
Hoary puccoon (*Lithospermum canescens*)	0.8		
Goldenrod (*Solidago* spp.)	0.7		
Pussy toes (*Antennaria* spp.)	0.7		
Chickweed (*Cerastium arvense*)	0.7		
Buttercup (*Ranunculus* spp.)	0.7		
Long-fruited thimbleweed (*Anemone cylindrica*)	0.5		
Fleabane (*Erigeron* spp.)	0.5		
Major Shrubs (3.2%)			
Poison ivy (*Toxicodendron radicans*)	3.2		
Other (2.4%)			
Scouringrush horsetail (*Equisetum hyemale*)	2.4		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=5)	49 (45-53)	Relative Native (%)	43.1	**Forage Production (kg/ha)**
Clubmoss (n=5)	7 (0-21)	Native Richness	26.7	
Litter (n=5)	43 (33-53)	Relative Exotic (%)	56.9	
Bare soil (n=5)	1 (0-2)	Exotic Richness	3	
Lichen (n=0)	-	Shannon's Diversity Index	1.9	
Moss (n=0)	-	Pielou's Evenness Index	0.62	

Moist Sand (MS) – APAD

State-and-Transition Diagram

Grassland



Description of Moist Sand S&T

There is a spectrum of moisture inherent among sites classified as Moist Sand because the classification requirement is water table existing temporarily anywhere between 0 and 50 cm of the soil surface. Most of our community data occurs on the drier end of the gradient. Communities that are wetter are expected to have less upland grasses, and more moisture-loving herbs and sedge decreasers. Hence, many of these communities and their transitions are provisional. Overall productivity of reference plant communities is expected to be high, attributed to tall, productive graminoids decreasers (e.g. **MS1** and **MS2**). Bluegrass and bentgrass are the exotics most likely to increase with high grazing pressure, with bentgrass more likely to invade moister sites. Some brush encroachment is possible.

MS1– APAD

Andropogon gerardii / Hesperostipa spartea – Carex

Big Bluestem / Porcupine-grass – Carex

Moist Sand

NO DATA

(n=0) The potential reference plant community established on moist sand sites with moderate to deep permanent water table would have dominance of some of the same decreaser grasses present on dunes, sand, and sandy loam ecosites (big bluestem (*Andropogon gerardii*), porcupine grass (*Hesperostipa spartea*), sandgrass (*Calamovilfa longifolia*), wheatgrasses (*Elymus* spp.)). If the water table is closer to the surface, these decreasers will be combined with hydrophytic decreasers like fowl bluegrass (*Poa palustris*), reedgrasses (*Calamagrostis* spp.), and wetland sedges (*Carex* spp.). These sites may be further indicated by presence of horsetails (*Equisetum* spp.) or rushes (*Juncus* spp.). As this reference plant community becomes altered from disturbance or heavy grazing, rushes, low-growing sedges, and forbs tend to increase, and possible invaders such as Kentucky bluegrass (*Poa pratensis*) and/or creeping bentgrass (*Agrostis stolonifera*) displace native graminoids.

Image 9. Association of big bluestem (*Andropogon gerardii*) and porcupine grass (*Hesperostipa spartea*) on imperfectly drained, coarse textured soil near Oak Lake.

MS2 – APAD

Andropogon gerardii – Hesperostipa spartea – Elymus repens

Big bluestem – Porcupine-grass – Quackgrass

Moist Sand

(n=1) This is an altered plant community that resembles the composition of the predicted potential reference plant community **MS1**, however exotic grasses have increased likely resulting from a history of disturbance. Herbaceous cover and forage production are likely high. Due to limited available data this is a provisional community.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (75.2%)			
Big bluestem (*Andropogon gerardii*)	40		
Porcupine-grass (*Hesperostipa spartea*)	20		
Quackgrass (*Elymus repens*)	10		
Kentucky bluegrass (*Poa pratensis*)	2.5		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	2.5		
Junegrass (*Koeleria macrantha*)	0.1		
Green Needlegrass (*Nassella viridula*)	0.1		
Major Forbs (20.3%)			
Northern bedstraw (*Galium boreale*)	7.5		
Prairie smoke (*Geum triflorum*)	7.5		
Sowthistle (*Sonchus* spp.)	2.5		
Breadroot (*Pediomelum esculentum*)	2		
Canada anemone (*Anemone canadensis*)	0.1		
Dandelion (*Taraxacum officinale*)	0.1		
Bastard toadflax (*Comandra umbellata*)	0.1		
Hoary puccoon (*Lithospermum canescens*)	<0.1		
White prairie aster (*Symphyotrichum falcatu,*)	<0.1		
Undifferentiated forbs	<0.1		
Major Shrubs (5.0%)			
Western snowberry (*Symphoricarpos occidentalis*)	5		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	78	Relative Native (%)	85	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	14	2209 kg/ha
Litter (n=1)	23	Relative Exotic (%)	15	
Bare soil (n=1)	0	Exotic Richness	4	
Lichen (n=0)	-	Shannon's Diversity Index	2.17	
Moss (n=1)	0	Pielou's Evenness Index	0.77	

MS3 – APAD

Andropogon gerardii / Poa pratensis

Big Bluestem / Kentucky Bluegrass

Moist Sand

(n=6) This community has been altered by increases in exotic grasses like Kentucky bluegrass and quackgrass which have replaced big bluestem, porcupine-grasses, and other decreasers. Decreasers still make up moderate amounts (~25%). It is difficult to tell if this community is in a trend of decline or recovery. Soil exposure is minimal.

Species Composition	% Biomass (n=5)	% Foliar Cover (n=1)	% Relative (n=6)
Major Graminoids			
Big bluestem (*Andropogon gerardii*)	18.3	52	20.6
Kentucky bluegrass (*Poa pratensis*)	19	7	16.5
Wetland sedge (*Carex* spp.)	5.5	0	4.6
Baltic rush (*Juncus balticus*)	5.1	0	4.2
Smooth brome (*Bromus inermis*)	4.6	0	3.8
Sedge (*Carex* spp.)	2.8	3	2.6
Tufted hairgrass (*Deschampsia cespitosa*)	2.3	0	1.9
Sandgrass (*Calamovilfa longifolia*)	2.2	0	1.8
Porcupine-grass (*Hesperostipa spartea*)	1.3	6	1.7
Creeping bentgrass (*Agrostis stolonifera*)	2	0	1.7
Blue grama (*Bouteloua gracilis*)	1.8	0	1.5
Common spikerush (*Eleocharis palustris*)	1.7	0	1.4
Little bluestem (*Schizachyrium scoparium*)	1.7	0	1.4
Prairie dropseed (*Sporobolus heterolepis*)	1.3	0	1.1
Junegrass (*Koeleria macrantha*)	1.3	0	1.1
Major Forbs			
Leafy spurge (*Euphorbia esula*)	0	19	2
Willow aster (*Symphyotrichum lanceolatum* var. *hesperium*)	1.7	0	1.4
Prairie sage (*Artemisia ludoviciana*)	1.4	0	1.2
Canada anemone (*Anemone canadensis*)	1.3	0	1.1
Strawberry (*Fragaria virginiana*)	1.3	0	1.1
Self-heal (*Prunella vulgaris*)	1.3	0	1
Black medic (*Medicago lupulina*)	1.1	0	0.9
Groundsel (*Senecio / Packera* spp.)	1	0	0.8
Canada goldenrod (*Solidago canadensis*)	1	0	0.8
Fringed sage (*Artemisia frigida*)	0.9	0	0.8
Major Trees and Shrubs			
Western snowberry (*Symphoricarpos occidentalis*)	1	56	6.7
Trembling aspen (*Populus tremuloides*)	1.3	0	1.1
Other			
Scouringrush horsetail (*Equisetum hyemale*)	2.1	0	1.8

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=6)	61 (48-67)	Relative Native (%)	89.2	**Forage Production (kg/ha)**
Clubmoss (n=3)	4 (0-12)	Native Richness	21.7	2094 kg/ha
Litter (n=6)	46 (33-86)	Relative Exotic (%)	10.8	
Bare soil (n=6)	2 (2)	Exotic Richness	2.3	
Lichen (n=1)	0	Shannon's Diversity Index	2.3	
Moss (n=4)	0	Pielou's Evenness Index	0.75	

MS4 – APAD

Carex – Poa pratensis – Equisetum / Sporobolus cryptandrus

Sedge – Kentucky Bluegrass – Horsetail – Sand dropseed

Moist Sand

(n=6) This significantly altered community is dominated by sedges (likely increasers) and exotic bluegrasses. If the sedges are decreasers this community could be a moderately altered state of the reference plant community. Other decreaser species are diverse but exist in small amounts.

Species Composition	% Biomass (n=6)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (65.7%)			
Sedge (*Carex* spp.)	27.5		
Kentucky bluegrass (*Poa pratensis*)	8.6		
Sand dropseed (*Sporobolus cryptandrus*)	5		
Fowl bluegrass (*Poa palustris*)	4.8		
Poverty oatgrass (*Danthonia spicata*)	3.1		
Northern reedgrass (*Calamagrostis stricta*)	2.9		
Smooth brome (*Bromus inermis*)	2.5		
Sheep fescue (*Festuca saximontana*)	2.1		
Rush (*Juncus* spp.)	1.8		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.7		
Exotic bluegrass (*Poa* spp.)	1.5		
Mat muhly (*Muhlenbergia richardsonis*)	0.7		
Fringed brome (*Bromus ciliatus*)	0.7		
Heller's rosette grass (*Dichanthelium oligosanthes*)	0.7		
Junegrass (*Koeleria macrantha*)	0.6		
Tickle hairgrass (*Agrostis scabra*)	0.5		
Major Forbs (28.7%)			
Undifferentiated forbs	5.1		
Cinquefoil (*Potentilla* spp.)	4.5		
Strawberry (*Fragaria virginiana*)	2.8		
Prairie sage (*Artemisia ludoviciana*)	1.8		
Clover (*Trifolium* spp.)	1.5		
Goldenrod (*Solidago* spp.)	1.3		
Pussy toes (*Antennaria* spp.)	1.3		
Northern bedstraw (*Galium boreale*)	1.2		
Prairie smoke (*Geum triflorum*)	1.1		
Common yarrow (*Achillea millefolium*)	1		
White sweetclover (*Melilotus alba*)	1		
Major Shrubs (0.4%)			
Other (5.2%)			
Horsetail (*Equisetum* spp.)	5		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=4)	67 (50-89)	Relative Native (%)	84.3	**Forage Production (kg/ha)**
Clubmoss (n=4)	1 (0-3)	Native Richness	18.2	
Litter (n=4)	73 (43-96)	Relative Exotic (%)	15.7	
Bare soil (n=4)	1 (0-2)	Exotic Richness	3.3	
Lichen (n=0)	-	Shannon's Diversity Index	2.2	
Moss (n=3)	0	Pielou's Evenness Index	0.78	

MS5 – APAD

Poa pratensis – Carex – Solidago

Kentucky Bluegrass – Sedge – Goldenrod

Moist Sand

(n=10) This severely altered community is dominated by Kentucky bluegrass, sedges, and increases in grazing tolerant forbs. Total relative exotic abundance is ~35%. There are increases in grazing tolerant native graminoids and forbs. Decreaser grasses from later seral states are present in small amounts, likely resulting in compromised forage production when compared to communities containing abundant big bluestem and porcupine-grass (**MS2** and **MS3**).

Species Composition	% Biomass (n=10)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (60.2%)			
Kentucky bluegrass (*Poa pratensis*)	21.3		
Sedge (*Carex* spp.)	18.2		
Porcupine-grass (*Hesperostipa spartea*)	2.5		
Sandgrass (*Calamovilfa longifolia*)	2.3		
Creeping bentgrass (*Agrostis stolonifera*)	2.2		
Plains reedgrass (*Calamagrostis montanensis*)	2.2		
Poverty oatgrass (*Danthonia spicata*)	1.8		
Smooth brome (*Bromus inermis*)	1.5		
Tickle hairgrass (*Agrostis scabra*)	1.5		
Creeping red fescue (*Festuca rubra*)	1.2		
Common timothy (*Phleum pratense*)	0.8		
Sheep fescue (*Festuca saximontana*)	0.7		
Major Forbs (35.6%)			
Goldenrod (*Solidago* spp.)	6.4		
Strawberry (*Fragaria virginiana*)	4		
Pussy toes (*Antennaria* spp.)	3.3		
White clover (*Trifolium repens*)	2.5		
Clover (*Trifolium* spp.)	1.9		
Prairie smoke (*Geum triflorum*)	1.8		
Bastard toadflax (*Comandra umbellata*)	1.7		
Prairie sage (*Artemisia ludoviciana*)	1		
Common yarrow (*Achillea millefolium*)	1		
Cinquefoil (*Potentilla* spp.)	0.9		
Chickweed (*Cerastium arvense*)	0.9		
Undifferentiated forbs	0.8		
Northern bedstraw (*Galium boreale*)	0.8		
Major Shrubs (2.5%)			
Other (1.7%)			
Horsetail (*Equisetum* spp.)	1.7		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=9)	65 (53-79)	Relative Native (%)	66.7	**Forage Production (kg/ha)**
Clubmoss (n=7)	3 (0-11)	Native Richness	19.2	1155 kg/ha
Litter (n=9)	47 (21-84)	Relative Exotic (%)	33.3	
Bare soil (n=9)	7 (0-19)	Exotic Richness	3.8	
Lichen (n=0)	-	Shannon's Diversity Index	2.4	
Moss (n=9)	7 (0-63)	Pielou's Evenness Index	0.76	

MS6 – APAD

Symphoricarpos occidentalis – Bromus inermis / Sporobolus cryptandrus – Hesperostipa curtiseta

Western Snowberry – Smooth Brome – Sand Dropseed – Western Porcupine-grass

Moist Sand

(n=3) This significantly altered community is in the early stages of shrub and smooth brome invasion. Some of the grass decreasers retained (western porcupine grass, awned wheatgrass, slender wheatgrass, and plains rough fescue) are unique from the proposed potential reference plant community, possibly due to spatial variation within the Aspen Parkland rangeland ecoregion.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=3)	% Relative (n=3)
Major Graminoids (48.7%)			
Smooth brome (*Bromus inermis*)		6.7	10.3
Sand dropseed (*Sporobolus cryptandrus*)		6.5	10.1
Western porcupine-grass (*Hesperostipa curtiseta*)		4.6	7.1
Kentucky bluegrass (*Poa pratensis*)		3.6	5.5
Needle and threadgrass (*Hesperostipa comata*)		3.2	4.9
Grassland sedge (*Carex* spp.)		2.1	3.2
Big bluestem (*Andropogon gerardii*)		1.7	2.6
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		1.2	1.8
Sandgrass (*Calamovilfa longifolia*)		1.2	1.8
Plains rough fescue (*Festuca hallii*)		0.5	0.8
Mat muhly (*Muhlenbergia richardsonis*)		0.2	0.3
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		0.2	0.3
Major Forbs (34.6%)			
Undifferentiated forbs		8	12.3
Northern bedstraw (*Galium boreale*)		3.5	5.4
Wild licorice (*Glycyrrhiza lepidota*)		2.3	3.6
Canada thistle (*Cirsium arvense*)		2	3.1
Meadowrue (*Thalictrum* spp.)		1.7	2.6
Cinquefoil (*Potentilla* spp.)		1.3	2.1
Prairie sage (*Artemisia ludoviciana*)		1	1.5
Strawberry (*Fragaria virginiana*)		0.8	1.3
Vetch (*Vicia* spp.)		0.5	0.8
Anemone (*Anemone* spp.)		0.3	0.5
Fringed sage (*Artemisia frigida*)		0.3	0.5
Silverleaf scurfpea (*Pediomelum argophyllum*)		0.3	0.5
Common yarrow (*Achillea millefolium*)		0.2	0.3
Prairie coneflower (*Ratibida columnifera*)		0.2	0.3
Major Shrubs (16.7%)			
Western snowberry (*Symphoricarpos occidentalis*)		9.1	14.1
Rose (*Rosa* spp.)		1.7	2.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	79.9	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	15	
Litter (n=0)	-	Relative Exotic (%)	20.1	
Bare soil (n=0)	-	Exotic Richness	2.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=0)	-	Pielou's Evenness Index	0.71	

MS7M (Modified) – APAD

Exotic *Poa – Agrostis stolonifera – Trifolium*

Exotic Bluegrass – Creeping Bentgrass - Clover

Moist Sand

(n=31) This is a **Modified** moist sand grassland community dominated by grazing tolerant exotic species (~70%). A history of overgrazing has likely caused the shift towards bluegrass and bentgrass. Very few decreasers remain in low abundance. Those decreasers that are present are indicative of imperfectly drained soils (northern reedgrass, fringed brome, marsh muhly, wetland sedge, and awned wheatgrass). Live herbaceous cover and productivity are high, while litter cover is low for a moist site.

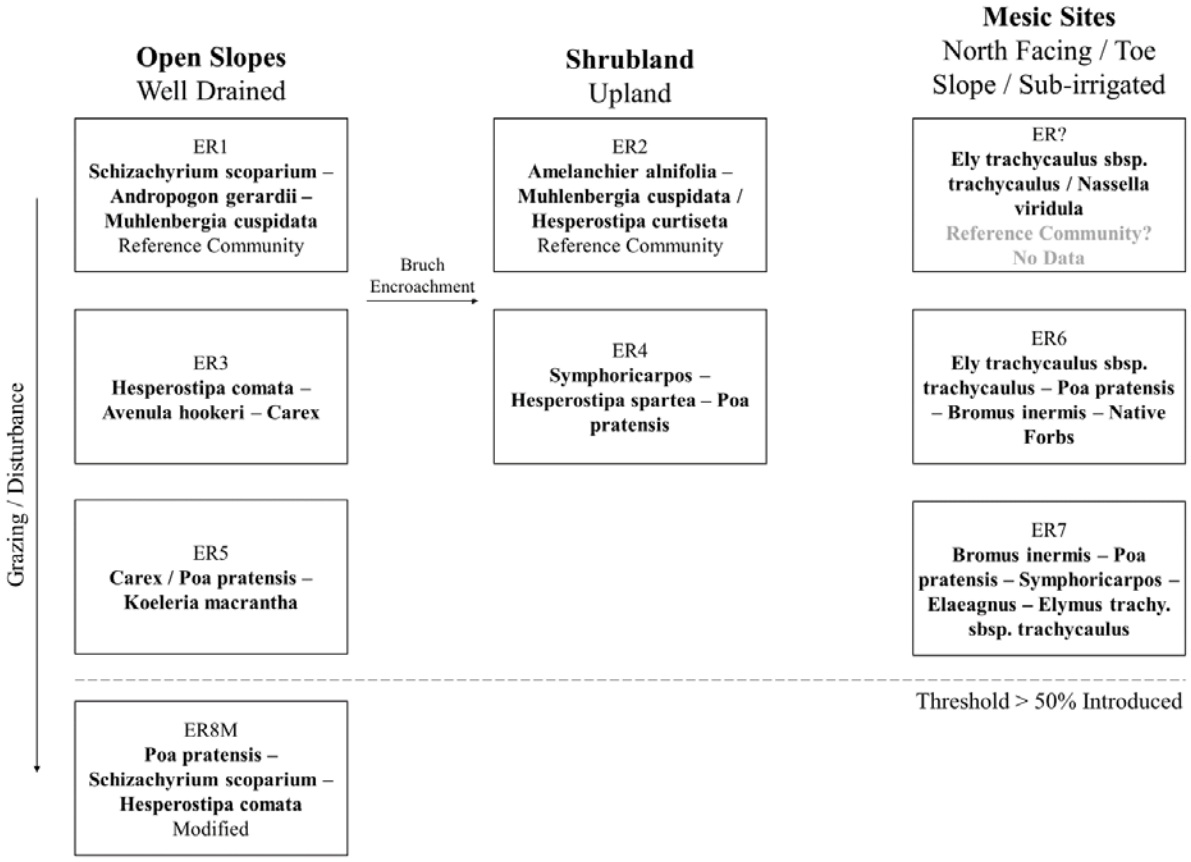
Species Composition	% Biomass (n=14)	% Foliar Cover (n=17)	% Relative (n=31)
Major Graminoids (71.1%)			
Exotic bluegrass (*Poa* spp.)	35.8	22.9	29.4
Creeping bentgrass (*Agrostis stolonifera*)	17.5	10.7	13.5
Sedge (*Carex* spp.)	8	4.6	6
Smooth brome (*Bromus inermis*)	4.6	3	3.3
Common timothy (*Phleum pratense*)	2.7	4	2.9
Quackgrass (*Elymus repens*)	1.5	2.8	2.6
Rush (*Juncus* spp.)	2.4	1	1.4
Poverty oatgrass (*Danthonia spicata*)	3.2	0	1.2
Canada bluegrass (*Poa compressa*)	0	1.8	1.1
Tufted hairgrass (*Deschampsia cespitosa*)	0	2.1	0.9
Northern reedgrass (*Calamagrostis stricta*)	1	0.8	0.8
Foxtail barley (*Hordeum jubatum*)	0	2	0.8
Reedgrass (*Calamagrostis* spp.)	0	1.3	0.6
Fringed brome (*Bromus ciliatus*)	0.1	1.1	0.5
Major Forbs (26.5%)			
Clover (*Trifolium* spp.)	1.2	13.7	7.1
Dandelion (*Taraxacum officinale*)	2.9	1	5.8
Black medic (*Medicago lupulina*)	0.4	5.1	2.6
Strawberry (*Fragaria virginiana*)	1.4	2.4	1.8
Pussy toes (*Antennaria* spp.)	1.1	1.4	1
White clover (*Trifolium repens*)	0.5	0	1
White sweetclover (*Melilotus alba*)	0.1	2.4	1
Thistle (*Cirsium* spp.)	0.5	1.3	0.8
Common plantain (*Plantago major*)	1.5	0	0.8
Aster (*Symphyotrichum* spp.)	0.8	0.8	0.7
Northern bedstraw (*Galium boreale*)	0.5	0.6	0.5
Major Shrubs (1.5%)			
Western snowberry (*Symphoricarpos occidentalis*)	0	1.3	0.6
Other (0.9%)			
Horsetail (*Equisetum* spp.)	1.8	0.2	0.8

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=30)	76 (39-100)	Relative Native (%)	29.4	**Forage Production (kg/ha)**
Clubmoss (n=9)	4 (0-21)	Native Richness	11.8	2057 kg/ha
Litter (n=30)	27 (1-79)	Relative Exotic (%)	70.6	
Bare soil (n=30)	4 (0-29)	Exotic Richness	5.7	
Lichen (n=0)	-	Shannon's Diversity Index	1.9	
Moss (n=30)	1 (0=5)	Pielou's Evenness Index	0.70	

Eroded Slopes (ER) – APAD

State-and-Transition Diagram

Grassland



Description of Eroded Slopes S&T

Eroded slopes are complex growing environments, whose communities vary as a result of slope steepness, aspect, position, and presence or absence of erosive forces from adjacent water courses. On well drained open slopes later seral communities often contain some proportion of plains muhly (*Muhlenbergia cuspidata*), which is an indicator of eroded slopes (**ER1**), in association with other decreasers. Open slopes are susceptible to shrub encroachment, with a lack of disturbance these areas can transition into tall shrublands and woodlands (not yet described), the earlier stages of encroachment are reported here (**ER2** and **ER4**). The open and woody slopes are assumed to be drier than the more mesic areas near sub-irrigated areas, at the toes of the slopes, or on north-facing slopes (**ER6** to **ER7**). Slope stability was not used to partition communities, but these separations could become apparent with more data. The decreaser-increaser concept was used to indicate successional level of these communities, even though many of these slopes may not be used for cattle grazing as they prefer more level terrain. Invaders remain at the lower end of the successional trajectory. Due to limited available data, communities with small sample sizes are provisional and expected to change.

ER1 – APAD

Schizachyrium scoparium – Andropogon gerardii– Muhlenbergia cuspidata

Little Bluestem – Big Bluestem – Plains Muhly

Eroded Slopes

(n=7) This is a **reference plant community** for well drained eroded slopes indicated by dominance of C4 grasses like bluestems and plains muhly. Community should lack exotic species but is likely susceptible to leafy spurge invasion.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=7)	% Relative (n=7)
Major Graminoids (88.8%)			
Little bluestem (*Schizachyrium scoparium*)		17.4	31.3
Big bluestem (*Andropogon gerardii*)		11.5	20.8
Plains muhly (*Muhlenbergia cuspidata*)		6.1	11.1
Blue grama (*Bouteloua gracilis*)		5.2	9.3
Sandgrass (*Calamovilfa longifolia*)		3.7	6.7
Needle and threadgrass (*Hesperostipa comata*)		2.6	4.6
Porcupine-grass (*Hesperostipa spartea*)		1.2	2.1
Thread-leaved sedge (*Carex filifolia*)		0.5	0.9
Sedge (*Carex* spp.)		0.2	0.4
Low sedge (*Carex duriuscula*)		0.2	0.4
Undifferentiated graminoids		0.2	0.3
Junegrass (*Koeleria macrantha*)		0.2	0.3
Sun sedge (*Carex inops* sbsp. *heliophila*)		0.1	0.3
Western wheatgrass (*Pascopyrum smithii*)		0.1	0.3
Major Forbs (6.4%)			
Fringed sage (*Artemisia frigida*)		0.6	1.1
American vetch (*Vicia americana*)		0.4	0.7
Tufted white prairie aster (*Symphyotrichum ericoides*)		0.4	0.7
Leafy spurge (*Euphorbia esula*)		0.3	0.5
Sunflower (*Helianthus* spp.)		0.3	0.5
Brown-eyed Susan (*Rudbeckia hirta*)		0.3	0.5
Indian breadroot (*Pediomelum esculentum*)		0.3	0.5
Northern bedstraw (*Galium boreale*)		0.3	0.5
Purple prairie clover (*Dalea purpurea*)		0.2	0.3
Bastard toadflax (*Comandra umbellata*)		0.1	0.2
Scarlet butterfly weed (*Oenothera suffrutescens*)		0.1	0.2
Narrow-leaved puccoon (*Lithospermum incisum*)		0.1	0.2
Silverleaf scurfpea (*Pediomelum argophyllum*)		0.1	0.2
Spreading dogbane (*Apocynum androsaemifolium*)		0.1	0.1
Major Shrubs (4.8%)			
Prairie rose (*Rosa arkansana*)		1.2	2.1
Western snowberry (*Symphoricarpos occidentalis*)		0.6	1
Saskatoon (*Amelanchier alnifolia*)		0.3	0.5

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	98.7	**Forage Production (kg/ha)**
Clubmoss (n=7)	0	Native Richness	15	
Litter (n=1)	0	Relative Exotic (%)	1.3	
Bare soil (n=0)	-	Exotic Richness	0.7	
Lichen (n=1)	0	Shannon's Diversity Index	1.7	
Moss (n=1)	0	Pielou's Evenness Index	0.63	

ER2 – APAD

Amelanchier alnifolia – Muhlenbergia cuspidata / Hesperostipa curtiseta

Saskatoon – Plains Muhly – Western Porcupine-grass

Eroded Slopes

(n=2) A potential **reference plant community** for shrubland mixed with grassland on eroded slopes. Saskatoon is a decreaser sensitive to disturbance, and relatively dominant in association with plains muhly and western porcupine-grass. Low exotic species cover and richness expected. Community could be in a transitional state towards a tall shrubland dominated by Saskatoon.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=2)	% Relative (n=2)
Major Graminoids (41.6%)			
Plains muhly (*Muhlenbergia cuspidata*)		7.8	16.2
Western porcupine-grass (*Hesperostipa curtiseta*)		7.5	15.7
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		1.8	3.7
Little bluestem (*Schizachyrium scoparium*)		1.8	3.7
Porcupine-grass (*Hesperostipa spartea*)		0.3	0.5
Junegrass (*Koeleria macrantha*)		0.3	0.5
Big bluestem (*Andropogon gerardii*)		0.3	0.5
Sun sedge (*Carex inops* sbsp. *heliophila*)		0.3	0.5
Major Forbs (14.1%)			
Northern bedstraw (*Galium boreale*)		1.8	3.7
Two-grooved milkvetch (*Astragalus bisulcatus*)		1.5	3.1
Leafy spurge (*Euphorbia esula*)		0.5	1
Wild licorice (*Glycyrrhiza lepidota*)		0.5	1
Common yarrow (*Achillea millefolium*)		0.3	0.6
Tufted white prairie aster (*Symphyotrichum ericoides*)		0.3	0.6
Bastard toadflax (*Comandra umbellata*)		0.3	0.5
Missouri goldenrod (*Solidago missouriensis*)		0.3	0.5
Smooth blue aster (*Symphyotrichum laeve*)		0.3	0.5
Stiff goldenrod (*Solidago rigida*)		0.3	0.5
Fringed sage (*Artemisia frigida*)		0.3	0.5
Wild blue flax (*Linum lewisii*)		0.3	0.5
Flexile milkvetch (*Astragalus flexuosus*)		0.3	0.5
Lily (*Lilium philadelphicum*)		0.3	0.5
Prairie sage (*Artemisia ludoviciana*)		0.1	0.1
Major Shrubs (44.3%)			
Saskatoon (*Amelanchier alnifolia*)		19	39.7
Wolf willow (*Elaeagnus commutata*)		1.5	3.1
Prairie rose (*Rosa arkansana*)		0.5	1
Kinnikinnick (*Arctostaphylos uva-ursi*)		0.3	0.5

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	97.1	**Forage Production (kg/ha)**
Clubmoss (n=2)	0	Native Richness	17.5	
Litter (n=0)	-	Relative Exotic (%)	2.9	
Bare soil (n=0)	-	Exotic Richness	1	
Lichen (n=0)	-	Shannon's Diversity Index	2.4	
Moss (n=0)	-	Pielou's Evenness Index	0.81	

ER3 – APAD

Hesperostipa comata – Avenula hookeri – Carex

Needle and Threadgrass – Hooker's Oatgrass – Sedge

Eroded Slopes

(n=3) This is an altered community where reference plant community (**ER1**) grasses are reduced and displaced by disturbance tolerant native grasses like needle and thread grass, sedge increasers, and disturbance tolerant forbs. High proportions of grasses typical of later seral states like Hooker's oatgrass and plains rough fescue are present. This community could be derived from a reference state dominated by these grasses. Kentucky bluegrass invasion is also possible.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=3)	% Relative (n=3)
Major Graminoids (76.8%)			
Needle and threadgrass (*Hesperostipa comata*)		24.9	27.2
Hooker's oatgrass (*Avenula hookeri*)		9.3	10.2
Sedge (*Carex* spp.)		8.3	9.1
Plains rough fescue (*Festuca hallii*)		6	6.6
Kentucky bluegrass (*Poa pratensis*)		5.7	6.2
Green needlegrass (*Nassella viridula*)		5.1	5.6
Western wheatgrass (*Pascopyrum smithii*)		2.3	2.5
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		1.3	1.5
Junegrass (*Koeleria macrantha*)		1.3	1.4
Intermediate oatgrass (*Danthonia intermedia*)		1.2	1.3
Western porcupine-grass (*Hesperostipa curtiseta*)		1.2	1.3
Slender wheatgrass (*Elymus trachycaulus* sbsp. *trachycaulus*)		1	1.1
Blue grama (*Bouteloua gracilis*)		0.8	0.9
Alkali cordgrass (*Spartina gracilis*)		0.5	0.5
Plains muhly (*Muhlenbergia cuspidata*)		0.3	0.4
Prairie dropseed (*Sporobolus heterolepis*)		0.3	0.4
Sand dropseed (*Sporobolus cryptandrus*)		0.3	0.4
Northern wheatgrass (*Elymus lanceolatus*)		0.2	0.2
Major Forbs (16.6%)			
Undifferentiated forbs		6.7	7.3
Fringed sage (*Artemisia frigida*)		2	2.2
Prairie sage (*Artemisia ludoviciana*)		1.8	2
Northern bedstraw (*Galium boreale*)		1.5	1.6
Dandelion (*Taraxacum officinale*)		0.8	0.9
Common yarrow (*Achillea millefolium*)		0.8	0.9
Prairie coneflower (*Ratibida columnifera*)		0.8	0.9
Silverleaf scurf pea (*Pediomelum argophyllum*)		0.3	0.4
Scarlet butterfly weed (*Oenothera suffrutescens*)		0.2	0.2
Canada thistle (*Cirsium arvense*)		0.2	0.2
Major Shrubs (6.6%)			
Rose (*Rosa* spp.)		6	6.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	91.2	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	15.3	
Litter (n=0)	-	Relative Exotic (%)	7.8	
Bare soil (n=0)	-	Exotic Richness	1.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.3	
Moss (n=0)	-	Pielou's Evenness Index	0.80	

ER4 – APAD

Symphoricarpos occidentalis – Hesperostipa spartea – Poa pratensis

Western Snowberry – Porcupine-grass – Kentucky Bluegrass

Eroded Slopes

(n=8) This native grassland community on eroded slopes that has been altered by shrub encroachment, primarily from western snowberry, and increases of Kentucky bluegrass. Later seral grasses have also been reduced, but a wide diversity of decreasers persist in small amounts.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=8)	% Relative (n=8)
Major Graminoids (61.6%)			
Porcupine-grass (*Hesperostipa spartea*)		19.7	16.7
Kentucky bluegrass (*Poa pratensis*)		10.2	8.6
Needle and threadgrass (*Hesperostipa comata*)		7.7	6.5
Grassland sedge (*Carex* spp.)		5	4.2
Wheatgrasses (*Agropyron / Elymus* spp.)		4.4	3.7
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		4	3.4
Needlegrasses (*Hesperostipa* spp.)		3.1	2.6
Little bluestem (*Schizachyrium scoparium*)		2.8	2.4
Blue grama (*Bouteloua gracilis*)		2.6	2.2
Junegrass (*Koeleria macrantha*)		2.1	1.7
Western wheatgrass (*Pascopyrum smithii*)		1.8	1.5
Green needlegrass (*Nassella viridula*)		1.7	1.4
Sloughgrass (*Beckmannia syzigachne*)		1.7	1.4
Prairie dropseed (*Sporobolus heterolepis*)		1	0.9
Sandgrass (*Calamovilfa longifolia*)		1	0.8
Plains reedgrass (*Calamagrostis montanensis*)		0.8	0.7
Sheep fescue (*Festuca saximontana*)		0.7	0.6
Undifferentiated graminoids		0.5	0.4
Mat muhly (*Muhlenbergia richardsonis*)		0.5	0.4
Smooth brome (*Bromus inermis*)		0.3	0.3
Plains rough fescue (*Festuca hallii*)		0.3	0.2
Fringed brome (*Bromus ciliatus*)		0.3	0.2
Major Forbs (15.6%)			
Undifferentiated forbs		12.8	10.9
Fringed sage (*Artemisia frigida*)		3.3	2.8
Purple prairie clover (*Dalea purpurea*)		1.1	1
Prairie crocus (*Pulsatilla patens*)		0.6	0.5
Goat's beard (*Tragopogon dubius*)		0.3	0.3
Major Shrubs (22.8%)			
Western snowberry (*Symphoricarpos occidentalis*)		24.1	20.4
Rose (*Rosa* spp.)		2	1.7
Wolf willow (*Elaeagnus commutata*)		0.6	0.5
Willow (*Salix* spp.)		0.3	0.2

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	89.1	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	13	
Litter (n=0)	-	Relative Exotic (%)	10.8	
Bare soil (n=7)	4 (0-19)	Exotic Richness	1.6	
Lichen (n=7)	6 (0-31)	Shannon's Diversity Index	2.0	
Moss (n=0)	-	Pielou's Evenness Index	0.77	

ER5 – APAD

Carex / Poa pratensis – Koeleria macrantha

Sedge / Kentucky Bluegrass – Junegrass

Eroded Slopes

(n=4) This is a significantly altered native grassland, where disturbance has favoured increases of upland sedge increasers, Kentucky bluegrass, and native grass increasers. Later seral grasses are present in low amounts. Some brush encroachment is possible.

Species Composition	% Biomass (n=2)	% Foliar Cover (n=2)	% Relative (n=4)
Major Graminoids (60.1%)			
Grassland sedge (*Carex* spp.)	12.3	10.3	11.5
Kentucky bluegrass (*Poa pratensis*)	11.8	10.3	11.2
Junegrass (*Koeleria macrantha*)	3.8	10.3	7.2
Needlegrasses (*Hesperostipa* spp.)	0	10	4.5
Blue grama (*Bouteloua gracilis*)	8.3	0	4.1
Porcupine-grass (*Hesperostipa spartea*)	7	0	3.5
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	4	0.3	2.9
Green needlegrass (*Nassella viridula*)	3.8	0.3	2.8
Plains muhly (*Muhlenbergia cuspidata*)	5.5	0	2.8
Plains rough fescue (*Festuca hallii*)	1.8	0.3	1.8
Big bluestem (*Andropogon gerardii*)	2.8	0	1.4
Western wheatgrass (*Pascopyrum smithii*)	2.3	0	1.1
Hooker's oatgrass (*Avenula hookeri*)	0.3	0.3	1
Northern wheatgrass (*Elymus lanceolatus*)	1.3	0	0.6
Major Forbs (32.3%)			
Northern bedstraw (*Galium boreale*)	4.3	2.8	4.1
Common yarrow (*Achillea millefolium*)	4.3	2.8	4.1
Curly-cup gumweed (*Grindelia squarrosa*)	7	0	3.5
Hoary puccoon (*Lithospermum canescens*)	4	0.3	2.9
Prairie sage (*Artemisia ludoviciana*)	3	0.3	2.4
Aster (*Symphyotrichum* spp.)	1	0.3	1.4
Bee balm (*Monarda fistulosa*)	0.8	0.3	1.3
Milkvetch (*Astragalus* spp.)	0.5	0.3	1.1
American vetch (*Vicia americana*)	0.5	0.3	1.1
Bastard toadflax (*Comandra umbellata*)	0.3	0.3	1
Silverweed cinquefoil (*Argentina ansernia*)	0	0.3	0.9
Yellow flax (*Linum rigidum*)	0	0.3	0.9
Prairie smoke (*Geum triflorum*)	1.8	0	0.9
Major Shrubs (7.6%)			
Western snowberry (*Symphoricarpos occidentalis*)	0	10	4.5
Northern snowberry (*Symphoricarpos albus*)	3	0	1.5
Rose (*Rosa* spp.)	0.8	0.3	1.3
Wolf willow (*Elaeagnus commutata*)	0	1	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=2)	49 (40-58)	Relative Native (%)	81.2	**Forage Production (kg/ha)**
Clubmoss (n=3)	16 (0-44)	Native Richness	11.2	
Litter (n=2)	33 (23-43)	Relative Exotic (%)	18.8	
Bare soil (n=2)	4 (3-5)	Exotic Richness	1	
Lichen (n=0)	-	Shannon's Diversity Index	2.5	
Moss (n=2)	0	Pielou's Evenness Index	0.86	

ER6 – APAD

Elymus trachycaulus* sbsp. *trachycaulus* – *Poa pratensis* – *Bromus inermis* – *Native Forbs

Slender Wheatgrass – Kentucky Bluegrass – Smooth Brome – Native Forbs

Eroded Slopes

(n=3) A severely altered native grassland that likely exists at lower slope positions or north facing slope resulting in relatively higher soil moisture. Slender wheatgrass would likely dominate the reference plant community for non-disturbed sites, here slender wheatgrass and other natives are displaced by non-native grasses and forbs (30%). Native plants indicative of high soil moisture like horsetail, wild licorice, and baltic rush are present in small amounts. Overall forbs are abundant, the palatable proportion of the stand may be reduced.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=3)	% Relative (n=3)
Major Graminoids (56.4%)			
Slender wheatgrass (*Elymus trachycaulus* sbsp *trachycaulus*)		27	26.5
Kentucky bluegrass (*Poa pratensis*)		14	13.7
Smooth brome (*Bromus inermis*)		11.9	11.6
Grassland sedge (*Carex* spp.)		3	2.9
Baltic rush (*Juncus balticus*)		1	1
Tickle hairgrass (*Agrostis scabra*)		0.5	0.5
Major Forbs (33.3%)			
Undifferentiated forbs		13.2	13
Cinquefoil (*Potentilla* spp.)		7.8	7.6
Wild liquorice (*Glycyrrhiza lepidota*)		5.2	5.1
Dandelion (*Taraxacum officinale*)		2	2
Canada thistle (*Cirsium arvense*)		1.5	1.5
Goldenrod (*Solidago* spp.)		1.4	1.4
Northern bedstraw (*Galium boreale*)		1.2	1.1
Perennial sowthistle (*Sonchus arvensis*)		0.5	0.5
Prairie coneflower (*Ratibida columnifera*)		0.3	0.3
Common yarrow (*Achillea millefolium*)		0.3	0.3
Vetch (*Vicia* spp.)		0.3	0.3
Fringed sage (*Artemisia frigida*)		0.2	0.2
Major Shrubs (9.1%)			
Western snowberry (*Symphoricarpos occidentalis*)		5	4.9
Wolf willow (*Elaeagnus commutata*)		3.2	3.1
Prickly rose (*Rosa acicularis*)		1.1	1.1
Other (1.2%)			
Horsetail (*Equisetum* spp.)		1.2	1.2

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	69.9	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	9.7	
Litter (n=0)	-	Relative Exotic (%)	30.1	
Bare soil (n=0)	-	Exotic Richness	2.7	
Lichen (n=0)	-	Shannon's Diversity Index	2.0	
Moss (n=0)	-	Pielou's Evenness Index	0.79	

ER7 – APAD

Bromus inermis – Poa pratensis – Symphoricarpos occidentalis – Elaeagnus commutata – Elymus trachycaulus* sbsp. *trachycaulus

Smooth Brome – Kentucky Bluegrass – Western Snowberry – Wolfwillow – Slender Wheatgrass

Eroded Slopes

(n=8) A severely altered community from **ER6** containing greater relative exotic cover (~40%) from exotic grasses, and greater diversity and cover from shrubs. Similar to **ER6** composition could indicate more mesic and nutrient rich soil indicative of lower slope position or north facing slopes.

Species Composition	% Biomass (n=0)	% Foliar Cover (n=8)	% Relative (n=8)
Major Graminoids (51.7%)			
Smooth brome (*Bromus inermis*)		21.3	20.7
Kentucky bluegrass (*Poa pratensis*)		14.5	14.1
Slender wheatgrass (*Elymus trachycaulus* sbsp *trachycaulus*)		5	4.9
Needle and threadgrass (*Hesperostipa comata*)		3.4	3.3
Quackgrass (*Elymus repens*)		2.1	2
Junegrass (*Koeleria macrantha*)		1.7	1.6
Grassland sedge (*Carex* spp.)		1.4	1.4
Crested wheatgrass (*Agropyron cristatum*)		1.1	1.1
Canada bluegrass (*Poa compressa*)		1.1	1
Green needlegrass (*Nassella viridula*)		0.6	0.5
Hooker's oatgrass (*Avenula hookeri*)		0.5	0.5
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)		0.3	0.3
Major Forbs (26.9%)			
Undifferentiated forbs		11.5	11.2
Canada thistle (*Cirsium arvense*)		2.3	2.3
Strawberry (*Fragaria virginiana*)		1.9	1.9
Wild liquorice (*Glycyrrhiza lepidota*)		1.9	1.9
Common alfalfa (*Medicago sativa*)		1.8	1.8
Pussy toes (*Antennaria* spp.)		1.7	1.6
Silverleaf scurfpea (*Pediomelum argophyllum*)		1.6	1.5
Prairie sage (*Artemisia ludoviciana*)		1.6	1.5
Fringed sage (*Artemisia frigida*)		1.4	1.4
Prairie coneflower (*Ratibida columnifera*)		0.6	0.6
Common yarrow (*Achillea millefolium*)		0.4	0.4
Goldenrod (*Solidago* spp.)		0.4	0.4
Major Shrubs (21.4%)			
Western snowberry (*Symphoricarpos occidentalis*)		9.9	9.6
Wolf willow (*Elaeagnus commutata*)		7.1	6.9
Poplar (*Populus* spp.)		2.5	2.4
Silver sage (*Artemisia cana*)		1.1	1.1
Rose (*Rosa* spp.)		0.7	0.7
Chokecherry (*Prunus virginiana*)		0.6	0.6

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	58.1	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	9.6	
Litter (n=0)	-	Relative Exotic (%)	41.9	
Bare soil (n=0)	-	Exotic Richness	3.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=0)	-	Pielou's Evenness Index	0.83	

ER8M (Modified) – APAD

Poa pratensis – Schizachyrium scoparium – Hesperostipa comata

Kentucky Bluegrass

Eroded Slopes

(n=1) This is a **Modified** native grassland invaded by Kentucky bluegrass, retaining native grasses that were relatively more dominant in previous states (**ER1, ER3**). Due to limited data this is a provisional community.

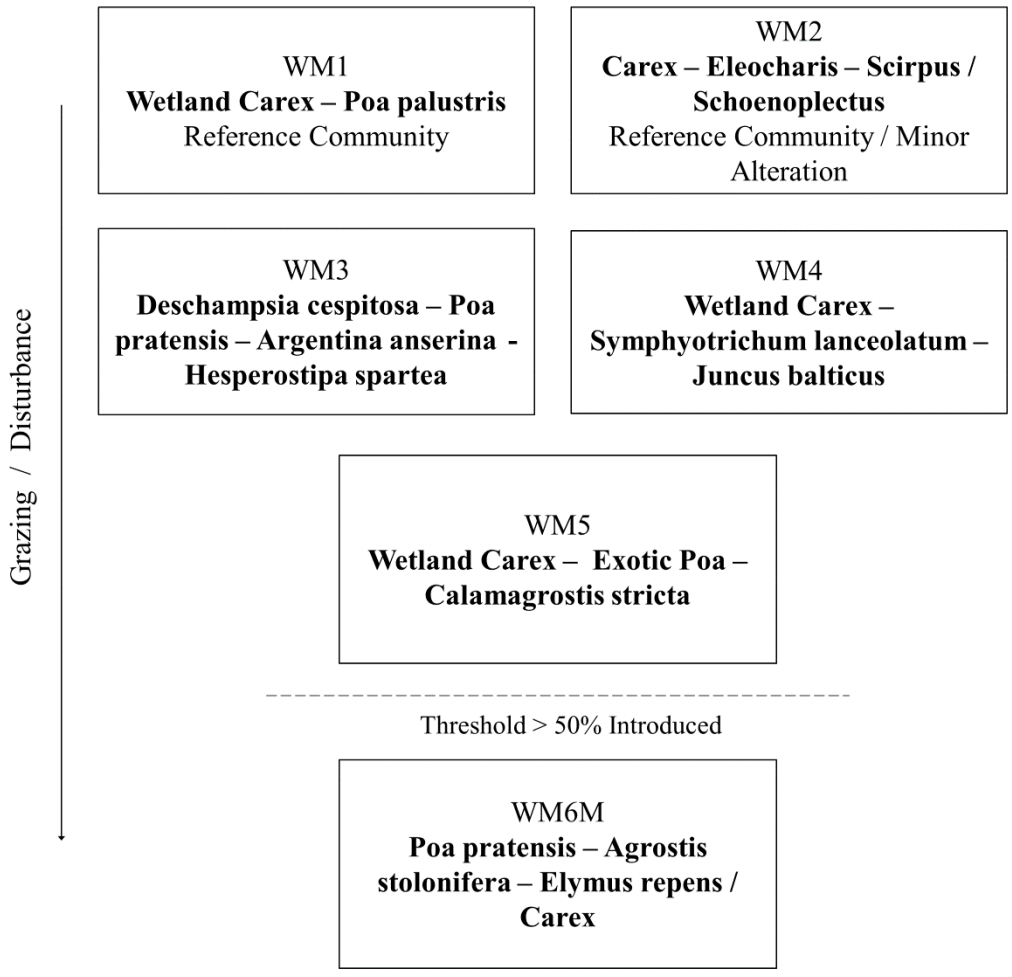
Species Composition	% Biomass (n=0)	% Foliar Cover (n=1)	% Relative (n=0)
Major Graminoids			
Kentucky bluegrass (*Poa pratensis*)		61.7	50.8
Little bluestem (*Schizachyrium scoparium*)		10	8.2
Needle and threadgrass (*Hesperostipa comata*)		7.5	6.2
Green needlegrass (*Nassella viridula*)		5	4.1
Northern wheatgrass (*Elymus lanceolatus*)		1.7	1.4
Major Forbs			
Northern bedstraw (*Galium boreale*)		5.8	4.8
Bee balm (*Monarda fistulosa*)		3.3	2.7
Blue lettuce (*Mulgedium pulchellum*)		2.5	2.1
Indian breadroot (*Pediomelum esculentum*)		2.3	1.9
Scarlet butterfly weed (*Oenothera suffrutescens*)		2.3	1.9
Dotted blazing star (*Liatris punctata*)		1.7	1.4
Narrow-leaved purple coneflower (*Echinacea angustifolia*)		1.7	1.4
Bastard toadflax (*Comandra umbellata*)		1.5	1.2
American vetch (*Vicia americana*)		0.8	0.7
Prairie sage (*Artemisia ludoviciana*)		0.5	0.4
Purple prairie clover (*Dalea purpurea*)		0.5	0.4
Skeleton weed (*Lygodesmia juncea*)		0.5	0.4
Purple locoweed (*Oxytropis lambertii*)		0.5	0.4
Prairie crocus (*Pulsatilla patens*)		0.5	0.4
Major Shrubs			
Prairie rose (*Rosa arkansana*)		6.7	5.5
Western snowberry (*Symphoricarpos occidentalis*)		4.2	3.4

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=0)	-	Relative Native (%)	49.2	**Forage Production (kg/ha)**
Clubmoss (n=1)	0	Native Richness	20	
Litter (n=1)	12	Relative Exotic (%)	50.8	
Bare soil (n=1)	0	Exotic Richness	1	
Lichen (n=1)	0	Shannon's Diversity Index	2.0	
Moss (n=0)	-	Pielou's Evenness Index	0.60	

Wet Meadow (WM) – APAD

State-and-Transition Diagram

Grassland



Description of Wet Meadow State and Transition Diagram

Wet meadows in later seral states are typically dominated by sedge decreasers, likely *Carex atherodes* or *C. aquatilis* (**WM1** and **WM2**), that are expected to decline with disturbances such as grazing. They are integral for the health, productivity, and ecological function of wet meadows. In later seral communities we expect sedges to be accompanied by hydrophytic decreaser grasses like reedgrasses (*Calamagrostis* spp.), manna-grasses (*Glyceria* spp.), and potentially tufted hair-grass (*Deschampsia cespitosa*). There is the potential for a late seral community dominated by these hydrophytic decreaser grasses, from which **WM3** likely originated. Both Kentucky bluegrass (*Poa pratensis*) and creeping bentgrass (*Agrostis stolonifera*) are expected to increase under favorable disturbance regimes, such as heavy grazing. Saturated soils of wet meadows, particularly in the spring and early summer, are susceptible to pugging and hummocking of soil by cattle. This creates microtopography that supports species associated with well drained soils, in **WM5** and **WM6M** these are typically weeds. More data collection is required to improve our understanding of wet meadow plant community shifts under diverse disturbance regimes. Thus, some communities like **WM3** are provisional and other descriptions are expected to change with additional data.

Image 10. Wet meadow in an early to mid seral state with abundant native forbs. Sedges have largely been displaced by non-native grasses.

WM1 – APAD

Carex (Wetland) – *Poa palustris*

Wetland Sedge – Fowl Bluegrass

Wet Meadow

(n=6) Potential **reference plant community** dominated by sedge decreasers (likely *Carex atherodes* or *C. aquatilis*) and fowl bluegrass, which are expected to decline with disturbance. Dominance of tall productive decreasers result in high community productivity. Presence of creeping bentgrass in the composition indicates the susceptibility to invasion. Moisture-loving forbs and shrubs exist in low abundance. Stand diversity and richness appears low, likely resulting from poor sedge differentiation, but is expected to be higher.

Species Composition	% Biomass (n=6)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (89.1%)			
Wetland sedge (*Carex* spp.)	48.3		
Undifferentiated sedge (*Carex* spp.)	11		
Fowl bluegrass (*Poa palustris*)	7.8		
Creeping bentgrass (*Agrostis stolonifera*)	7.5		
Northern reedgrass (*Calamagrostis stricta* ssp. *inexpansa*)	4.6		
Canary reedgrass (*Phalaris arundinacea*)	3.7		
Baltic rush (*Juncus balticus*)	2.2		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.1		
Spike-rush (*Eleocharis* spp.)	1		
Common spike-rush (*Eleocharis palustris*)	0.8		
Cattail (*Typha latifolia*)	0.6		
Bulrush (*Scirpus* spp.)	0.6		
Major Forbs (9.6%)			
Common water plantain (*Alisma plantago-aquatica*)	2.5		
Willow aster (*Symphyotrichum lanceolatum* var. *hesperium*)	2		
Dandelion (*Taraxacum officinale*)	1.7		
Water smartweed (*Polygonum amphibium*)	1		
Field mint (*Mentha arvensis*)	0.9		
Canada thistle (*Cirsium arvense*)	0.6		
Canada violet (*Viola canadensis*)	0.4		
Water plantain (*Alisma* spp.)	0.3		
Silverweed cinquefoil (*Argentina ansernia*)	0.2		
Western water-horehound (*Lycopus asper*)	0.1		
Major Shrubs (1.3%)			
Willow (*Salix* spp.)	1		
Trembling aspen (*Populus tremuloides*)	0.3		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=6)	46 (18-80)	Relative Native (%)	90.3	**Forage Production (kg/ha)**
Clubmoss (n=1)	0.3	Native Richness	7.3	3030 kg/ha
Litter (n=6)	26 (7-81)	Relative Exotic (%)	9.7	
Bare soil (n=6)	4 (0-25)	Exotic Richness	1.0	
Lichen (n=0)	-	Shannon's Diversity Index	1.1	
Moss (n=6)	16 (0-54)	Pielou's Evenness Index	0.51	

WM2 – APAD

Carex – Eleocharis – Scirpus / Schoenoplectus

Sedge – Spikerush – Bulrush

Wet Meadow

(n=5) This is an alternative **reference plant community** where sedges contribute to ~70% of the composition in association with spike-rushes and bulrushes, which could represent soils with greater soil saturation than **WM1**. Dominance of tall, productive decreasers would likely result in a productive community like **WM1**. Non-native plants are absent in the composition. A handful of moisture-loving forbs are expected.

Species Composition	% Biomass (n=5)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (95.5%)			
Undifferentiated sedge (*Carex* spp.)	58.4		
Grassland sedge (*Carex* spp.)	11.5		
Spike-rush (*Eleocharis* spp.)	6.5		
Bulrush (*Scirpus* spp.)	6		
Reedgrass (*Calamagrostis* spp.)	4.1		
Rush (*Juncus* spp.)	4		
Slough sedge (*Carex atherodes*)	1.4		
Seaside arrowgrass (*Triglochin maritima*)	0.9		
Soft-stem bulrush (*Schoenoplectus tabernaemontani*)	0.9		
Baltic rush (*Juncus balticus*)	0.8		
Marsh reedgrass (*Calamagrostis canadensis*)	0.8		
Canary reedgrass (*Phalaris arundinacea*)	0.5		
Cattail (*Typha latifolia*)	0.3		
Prairie chordgrass (*Spartina pectinata*)	0.1		
Sloughgrass (*Beckmannia syzigachne*)	0.1		
Scratchgrass (*Muhlenbergia asperifolia*)	0.1		
Major Forbs (4.5%)			
Hemlock waterparsnip (*Sium suave*)	0.6		
Western water-horehound (*Lycopus asper*)	0.6		
Silverweed cinquefoil (*Argentia ansernia*)	0.5		
Knotweed (*Polygonum* spp.)	0.4		
Marsh skull cap (*Scutellaria galericulata*)	0.3		
Hairy hedge-nettle (*Stachys pilosa*)	0.3		
Field mint (*Mentha arvensis*)	0.2		
Aster (*Symphyotrichum* spp.)	0.2		
Marsh hedge-nettle (*Stachys palustris*)	0.1		
Undifferentiated forbs	0.1		
Hemp dogbane (*Apocynum cannabinum*)	0.1		
Marsh bellflower (*Campanula aparinoides*)	0.1		
Common bladderwort (*Utricularia vulgaris*)	0.1		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=5)	31 (15-53)	Relative Native (%)	100	**Forage Production (kg/ha)**
Clubmoss (n=5)	0.4 (0-2)	Native Richness	11.2	
Litter (n=5)	42 (8-88)	Relative Exotic (%)	0	
Bare soil (n=5)	0	Exotic Richness	0	
Lichen (n=0)	-	Shannon's Diversity Index	1.0	
Moss (n=5)	6 (0-17)	Pielou's Evenness Index	0.43	

WM3 – APAD

Deschampsia cespitosa – Poa pratensis – Argentina anserina – Hesperostipa spartea

Wetland Sedge – Bulrush – Spike-rush

Wet Meadow

(n=1) Community with alteration from Kentucky blugrass, likely from a state where tufted hairgrass and porcupine-grass were dominant. Productivity is high but has likely been compromised by abundant increasers like bluegrass and silverweed cinquefoil. Due to limited data this is a provisional community.

Species Composition	% Biomass (n=1)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (62.4%)			
Tufted hairgrass (*Deschampsia cespitosa*)	32.5		
Kentucky bluegrass (*Poa pratensis*)	20		
Porcupine-grass (*Hesperostipa spartea*)	7.5		
Wetland sedge (*Carex* spp.)	2.6		
Common spike-rush (*Eleocharis palustris*)	0.1		
Fowl manna-grass (*Glyceria striata*)	0.1		
Major Forbs (34.9%)			
Silverweed cinquefoil (*Argentina anserina*)	17.5		
Water-horehound (*Lycopus americanus*)	5		
Violet (*Viola* spp.)	5		
Fringed loosestrife (*Lysimachia ciliata*)	5		
Willow aster (*Symphyotrichum lanceolatum* var. *hesperium*)	2.6		
Blue-eyed grass (*Sisyrinchium montanum*)	0.1		
Canada anemone (*Anemone canadensis*)	0.1		
Major Shrubs (2.6%)			
Willow (*Salix* spp.)	2.5		
Red-osier dogwood (*Cornus sericea*)	0.1		
Other (0.1%)			
Horsetail (*Equisetum* spp.)	0.1		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=1)	65	Relative Native (%)	80.1	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	15	2114 kg/ha
Litter (n=1)	64	Relative Exotic (%)	19.9	
Bare soil (n=1)	0	Exotic Richness	1	
Lichen (n=0)	-	Shannon's Diversity Index	1.9	
Moss (n=1)	0	Pielou's Evenness Index	0.70	

WM4 – APAD

Carex* (Wetland) – *Symphyotrichum lanceolatum – Juncus balticus

Wetland Sedge – Willow Aster – Baltic Rush

Wet Meadow

(n=4) Altered community retaining dominance of wetland sedge decreasers associated with forb increasers like willow aster and silverweed cinquefoil and graminoid increasers like baltic rush. Non-native graminoid and forb increasers are present in relatively high cover and diversity. However, overall productivity remains high but the palatable proportion is relatively lower than **WM1** and **WM2**. Pugging and hummocking of wet meadow soil creates microtopography that supports species associated with well drained soils.

Species Composition	% Biomass (n=4)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (59.5%)			
Wetland sedge (*Carex* spp.)	22.5		
Baltic rush (*Juncus balticus*)	7.5		
Kentucky bluegrass (*Poa pratensis*)	7.1		
Common spike-rush (*Eleocharis palustris*)	4.4		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	4.4		
Quackgrass (*Elymus repens*)	3.8		
Canary reedgrass (*Phalaris arundinacea*)	3.8		
Creeping bentgrass (*Agrostis stolonifera*)	3.3		
Northern reedgrass (*Calamagrostis stricta* sbsp. *inexpansa*)	1.3		
Tall manna grass (*Glyceria grandis*)	1.3		
Fowl manna-grass (*Glyceria striata*)	0.4		
Major Forbs (37.5%)			
Willow aster (*Symphyotrichum lanceolatum* var. *hesperium*)	13.3		
Silverweed cinquefoil (*Argentia ansernia*)	6.3		
Field mint (*Mentha arvensis*)	4.4		
Violet (*Viola* spp.)	3.3		
Water-horehound (*Lycopus americanus*)	2.9		
Sowthistle (*Sonchus* spp.)	2.3		
Self-heal (*Prunella vulgaris*)	1.3		
Dandelion (*Taraxacum officinale*)	1.1		
Common plantain (*Plantago major*)	0.8		
Hemlock waterparsnip (*Sium suave*)	0.6		
Common milkweed (*Asclepias speciosa*)	0.6		
American vetch (*Vicia americana*)	0.6		
Major Shrubs (1.7%)			
Chokecherry (*Prunus virginiana*)	1.3		
Willow (*Salix* spp.)	0.4		
Other (1.3%)			
Horsetail (*Equisetum* spp.)	1.3		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=4)	60 (55-68)	Relative Native (%)	81.7	**Forage Production (kg/ha)**
Clubmoss (n=0)	-	Native Richness	11.0	2772 kg/ha
Litter (n=4)	15 (10-20)	Relative Exotic (%)	18.3	
Bare soil (n=4)	3 (0-10)	Exotic Richness	4.3	
Lichen (n=0)	-	Shannon's Diversity Index	2.0	
Moss (n=4)	14 (5-23)	Pielou's Evenness Index	0.75	

WM5 – APAD

Carex*– Exotic *Poa* – *Calamagrostis stricta

Sedge – Exotic Bluegrass – Northern Reedgrass

Wet Meadow

(n=9) This native community has been significantly altered by disturbance, resulting in reduced sedges and other decreasers. Grazing tolerant and disturbance induced native and non-native species are abundant, primarily exotic bluegrasses. Pugging and hummocking of wet meadow soil creates microtopography that supports species associated with well drained soils, various weeds in this case. Relative to previous states decline in moss cover.

Species Composition	% Biomass (n=9)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (74.7%)			
Undifferentiated sedge (*Carex* spp.)	27.8		
Exotic bluegrass (*Poa* spp.)	15.1		
Northern reedgrass (*Calamagrostis stricta* sbsp. *stricta*)	6.4		
Rush (*Juncus* spp.)	5.7		
Creeping bentgrass (*Agrostis stolonifera*)	4.4		
Bulrush (*Scirpus* spp.)	2.6		
Foxtail barley (*Hordeum jubatum*)	2.2		
Awned wheatgrass (*Elymus trachycaulus* sbsp. *subsecundus*)	1.3		
Quackgrass (*Elymus repens*)	1.3		
Western wheatgrass (*Pascopyrum smithii*)	1.1		
Canary reedgrass (*Phalaris arundinacea*)	0.9		
Spike-rush (*Eleocharis* spp.)	0.8		
Wheatgrass/Ryegrass (*Elymus* spp.)	0.8		
Tickle hairgrass (*Agrostis scabra*)	0.6		
Major Forbs (19.6%)			
Silverweed cinquefoil (*Argentia ansernia*)	3.7		
Clover (*Trifolium* spp.)	1.9		
Undifferentiated forbs	1.6		
Northern bedstraw (*Galium boreale*)	1.6		
Sow thistle (*Sonchus* spp.)	1.3		
Common yarrow (*Achillea millefolium*)	1.1		
Dandelion (*Taraxacum officinale*)	1		
Pussy toes (*Antennaria* spp.)	0.8		
Aster (*Symphyotrichum* spp.)	0.8		
Marsh hedge-nettle (*Stachys palustris*)	0.6		
Major Shrubs (2.5%)			
Rose (*Rosa* spp.)	1.6		
Shrubby cinquefoil (*Dasiphora fruticosa*)	0.5		
Other (3.1%)			
Horsetail (*Equisetum* spp.)	3.1		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	60 (43-85)	Relative Native (%)	73.8	**Forage Production (kg/ha)**
Clubmoss (n=7)	0.3 (0-2)	Native Richness	14.4	
Litter (n=7)	67 (45-98)	Relative Exotic (%)	26.2	
Bare soil (n=7)	5 (0-21)	Exotic Richness	3.4	
Lichen (n=0)	-	Shannon's Diversity Index	2.1	
Moss (n=7)	0.3 (0-2)	Pielou's Evenness Index	0.73	

WM6M (Modified) – APAD

Poa pratensis – Agrostis stolonifera – Elymus repens / Carex

Kentucky Bluegrass – Creeping Bentgrass – Quackgrass / Sedge

Wet Meadow

(n=7) Significant disturbance has displaced wet meadow decreasers with exotic increasers resulting in a **Modified** community. Kentucky bluegrass and creeping bentgrass which were present in low abundance at previous states have displaced productive native plants in a disturbance regime that would improve their competitiveness, like heavy grazing. Productivity is relatively reduced. Pugging and hummocking of wet meadow soil creates microtopography that supports species associated with well drained soils, various weeds in this case.

Species Composition	% Biomass (n=7)	% Foliar Cover (n=0)	% Relative (n=0)
Major Graminoids (74.0%)			
Kentucky bluegrass (*Poa pratensis*)	25		
Creeping bentgrass (*Agrostis stolonifera*)	21.6		
Quackgrass (*Elymus repens*)	7.4		
Wetland sedge (*Carex* spp.)	4.1		
Undifferentiated sedge (*Carex* spp.)	3.5		
Common timothy (*Phleum pratense*)	2.5		
Canary reedgrass (*Phalaris arundinacea*)	1.8		
Smooth brome (*Bromus inermis*)	1.7		
Baltic rush (*Juncus balticus*)	1.4		
Rush (*Juncus* spp.)	1.4		
Tickle hairgrass (*Agrostis scabra*)	1		
Junegrass (*Koeleria macrantha*)	0.7		
Northern reedgrass (*Calamagrostis stricta* sbsp. *inexpansa*)	0.4		
Major Forbs (20.3%)			
Clover (*Trifolium* spp.)	4.5		
Silverweed cinquefoil (*Argentia ansernia*)	3		
Dandelion (*Taraxacum officinale*)	3		
Canada thistle (*Cirsium arvense*)	1.6		
Common plantain (*Plantago major*)	1.4		
White clover (*Trifolium repens*)	1.4		
Common yarrow (*Achillea millefolium*)	1		
Cinquefoil (*Potentilla* spp.)	0.7		
Pussy toes (*Antennaria* spp.)	0.6		
Field mint (*Mentha arvensis*)	0.5		
Swamp thistle (*Cirsium muticum*)	0.5		
Major Shrubs (1.6%)			
Trembling aspen (*Populus tremuloides*)	0.9		
Other (4.1%)			
Horsetail (*Equisetum* spp.)	4.1		

Structure	%	Origin and Diversity		Productivity
Herbaceous (n=7)	76 (67-83)	Relative Native (%)	20.0	**Forage Production (kg/ha)**
Clubmoss (n=4)	0	Native Richness	9.7	2436 kg/ha
Litter (n=7)	37 (10-78)	Relative Exotic (%)	80.0	
Bare soil (n=7)	8 (0-23)	Exotic Richness	6.0	
Lichen (n=0)	-	Shannon's Diversity Index	1.8	
Moss (n=7)	4 (0-11)	Pielou's Evenness Index	0.68	

8. Literature Cited

Abouguendia, Z. 1990. Range plan development. A practical guide to planning for management and improvement of Saskatchewan rangeland. New Pasture and Grazing Technology Project.

Adams, B. W., Ehlert, G., Stone, C., Lawrence, D., Alexander, M., Willoughby, M., Hincz, C., Moisey, D., Burkinshaw, A., Carlson, J. and France, K. 2005. Rangeland health assessment for grassland, forest and tame pasture. Public Lands and Forests Division, Alberta Sustainable Resource Development.

Alexander, M.J.1995. The response of mature decadent and healthy sapling aspen forest communities to prescribed burning and controlled livestock grazing. M.Sc. thesis, University of Alberta, Department of Plant Science, Edmonton, Alberta

Archibold, O.W., Ripley, E.A., and Delanoy, L. 2003. Effects of season burning on the microenvironment of fescue prairie in central Saskatchewan. Canadian Field-Naturalist **117**(2):257-266.

Bailey, A.W., and Wroe, R.W. 1974. Aspen invasion in a portion of the Alberta Parklands. Journal of Range Management **27**(4):263-266.

Bork, E. W., Adams, B. W., and Willms, W. D. 2002. Resilience of foothills rough fescue, *Festuca campestris*, rangeland to wildfire. Canadian Field-Naturalist **116**(1):51-59.

Bork, E.W., Carlyle, C.N., Cahill, J.F., Haddow, R.E. and Hudson, R.J., 2013. Disentangling herbivore impacts on *Populus tremuloides*: a comparison of native ungulates and cattle in Canada's Aspen Parkland. Oecologia **173**(3):895-904.

Briske, D.D., Fuhlendorf, S.D. and Smeins, F.E. 2005. State-and-transition models, thresholds, and rangeland health: a synthesis of ecological concepts and perspectives. Rangeland Ecology & Management **58**(1):1-10.

Brouillet, L., Coursol, F., Meades, S.J., Favreau, M., Anions, M., Bélisle, P. and Desmet, P. 2017. VASCAN, the Database of Vascular Plants of Canada. http://data.canadensys.net/vascan/

Chhin, S. and Wang, G.G. 2002. Spatial and temporal pattern of white spruce regeneration within mixed-grass prairie in the Spruce Woods Provincial Park of Manitoba. Journal of Biogeography **29**(7):903-912.

Chorney, B. and Josephson, R. 2000. A survey of pasture management on the Canadian prairies with emphasis on rotational grazing and managed riparian areas. M.Sc. Thesis, University of Manitoba, Department of Agricultural Economics and Farm Management, Winnipeg, Manitoba.

Clements, F.E. 1916. Plant succession: an analysis of the development of vegetation. Carnegie Institution of Washington.

Coupland, R.T., and Brayshaw, T.C.1953. The fescue grassland in Saskatchewan. Ecology **34**(2):386-405.

DeKeyser, E.S., Dennhardt, L.A., and Hendrickson, J. 2015. Kentucky bluegrass (*Poa pratensis*) invasion in the Northern Great Plains: a story of rapid dominance in an endangered ecosystem. Weed Science **64**(3):409-420.

Desserud, P.A, and Naeth, M.A. 2013. Natural recovery of rough fescue (*Festuca hallii* (Vasey) Piper) grassland after disturbance by pipeline construction in central Alberta, Canada. Natural Areas Journal **33**(1):91-98.

Donkor, N.T., Gedir, J.V., Hudson, R.J., Bork, E.W., Chanasyk, D.S., and Naeth, M.A. 2002. Impacts of grazing systems on soil compaction and pasture production in Alberta. Canadian Journal of Plant Science **82**(1):1-8.

Ecological Stratification Working Group. 1995. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Center for Land and Biological Resource Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull. http://sis.agr.gc.ca/cansis/publications/ecostrat/cad_report.pdf

Elsinger, M.E. 2009. Reclamation status of plains rough fescue grasslands at Rumsey Block after well site and pipeline disturbance. M.Sc. Thesis, University of Alberta, Department of Renewable Resources. Edmonton, Alberta.

Elsinger, M.E., Thompson, D.J., and M. Schellenberg. 2016. Discovering Potential to Improve Cover of Dominant Tallgrass Species in Native or Naturalized Pastures in Manitoba. pp. 199-202. *In* Kjoss, V.A. (ed.) 2016. Prairie: It's a Happening Place. Proceedings of the 11th Prairie Conservation and Endangered Species Conference. 16-18 February 2016, Saskatoon, Saskatchewan. Saskatchewan Prairie Conservation Action Plan, Regina, Saskatchewan. 265 pp. http://www.pcesc.ca/media/24013/pcesc-11th-proceedings-april-2016-final-02may2016.pdf

Gage, A. M., Olimb, S. K. and Nelson, J. 2016. Plowprint: Tracking cumulative cropland expansion to target grassland conservation. Great Plains Research **26**(2):107-116.

Gauthier, D. A. and Wiken, E. B. 2003. Monitoring the conservation of grassland habitats, prairie ecozone, Canada. Environmental Monitoring and Assessment **88**(1):343-364.

Havstad, K.M., Peters, D.P., Skaggs, R., Brown, J., Bestelmeyer, B., Fredrickson, E., Herrick, J. and Wright, J. 2007. Ecological services to and from rangelands of the United States. Ecological Economics **64**(2):261-268.

Henderson, D.C. and Koper, N. 2014. Historic distribution and ecology of tall-grass prairie in Western Canada. Proceedings of the 23rd North American Prairie Conference **23**:40-49. https://greatplainsnaturalsciencesociety.files.wordpress.com/2017/01/pdf-henderson-napc.pdf

Higgs, C.D. 1998. A wildlife resource inventory of the Upper Assiniboine Wildlife Management Area and other designated and protected lands in western Manitoba. Technical Report No. 98-02w. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

Higgs, C.D. 2013. Prairie inventory – Spruce Woods Provincial Park. Scatliff + Miller + Murray Inc. Winnipeg, MB. Project File #: 4191-2013/14.

Hohn, S.L., and Parsons, R.J. 1993. Lauder Sandhills Wildlife Management Area natural resources inventory. Technical Report No. 93-01. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

Johnston, A., Dormaar, J. F. and Smoliak, S. 1971. Long-term grazing effects on fescue grassland soils. Journal of Range Management **24**(3):185-188.

Jones, B.E., Rickman, T.H., Vazquez, A., Sado, Y. and Tate, K.W. 2005. Removal of encroaching conifers to regenerate degraded aspen stands in the Sierra Nevada. Restoration Ecology **13**(2):373-379.

Kupsch, T., France, K., Loonen, H., Burkinshaw, A., Willoughby, M. and McNeil, R. L. 2013. Guide to Range Plant Community Types and Carrying Capacity for the Central Parkland Subregion of Alberta. Alberta Sustainable Resource Development, Government of Alberta.

Legendre, P. and Legendre, L.F. 2012. Numerical ecology. Elsevier.

Limb, R.F., Fuhlendorf, S.D., Engle, D.M. and Kerby, J.D. 2011. Growing-season disturbance in tallgrass prairie: evaluating fire and grazing on *Schizachyrium scoparium*. Rangeland Ecology and Management **64**(1):28-36.

Looman, J. 1969. The fescue grasslands of western Canada. Vegetatio **19**(1-6):128-145.

Manitoba Forage and Grassland Association [MFGA]. 2017. Draft Manitoba Range and Pasture Health Assessment Workbook: Native Grassland, Tame Pasture, and Forested Rangeland. *Edited by* R. Whidden. http://mfga.net/projects/current-projects/manitoba-ecosite-and-rangeland-health-initiative/

Manitoba's Protected Areas Initiative. 2004. Manitoba's Natural Regions [map]. Accessed from Manitoba Wildlands [website]. 2014. http://manitobawildlands.org/maps/MB_natural_regions_2004.jpg

McCartney, D. H. 1993. History of grazing research in the Aspen Parkland. Canadian Journal of Animal Science **73**(4):749-763.

Naeth, M.A. Bailey, A.W., Pluth, D.J., Chanasyk, D.S., and Hardin, R.T. 1991. Grazing impacts on litter and soil organic matter in mixed prairie and fescue grassland. Journal of Range Management **44**(1):7-12.

Neily, P. and Strutt, K. 2000. Whitemud Watershed Wildlife Management Area wildlife inventory Edrans and Hummerston units. Technical Report No. 2000-03W. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

Oksanen, J., Blanchet, F.G, Friendly, M., Kindt, R, Legendre, P., McGlinn, D., Minchin, P.R., O'Hara, R.B., Simpson, G.L., Solymos, P., Stevens, M.H.H., Szoecs, E., and Wagner, H. 2017. vegan: Community Ecology Package. R package version 2.4-4. http://CRAN.R-project.org/package=vegan

Parsons, R. J. 1995. Bernice Wildlife Management Area natural resources inventory. Technical Report No. 95-03. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

Parsons, R. J., and Buck, R. M. 1994. Portage Sandhills Wildlife Management Area natural resources inventory. Technical Report No. 94-02. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

Parsons, R. J., and Gifford, M. M. 1994. Souris River Bend Wildlife Management Area natural resources inventory. Technical Report No. 95-01. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

Parsons, R. J., Hohn, S. L., Davis, S., and Smet, K. D. D. 1993. Broomhill Sandhills Wildlife Management Area natural resources inventory. Technical Report No. 94-01. Wildlife Branch, Manitoba Conservation, Winnipeg, Manitoba.

R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Reed, F., Roath, R., and Bradford, D. 1999. The Grazing Response Index: A Simple and Effective Method to Evaluate Grazing Impacts. Rangelands **21**(4): 3-6

Sinkins, P. A. and Otfinowski, R. 2012. Invasion or retreat? The fate of exotic invaders on the northern prairies, 40 years after cattle grazing. Plant Ecology **213**(8):1251-1262.

Smith, R.E., H. Veldhuis, G.F. Mills, R.G. Eilers, W.R. Fraser, and G.W. Lelyk. 1998. Terrestrial Ecozones, Ecoregions, and Ecodistricts of Manitoba: an ecological stratification of Manitoba's natural landscapes. Agriculture and Agri-Food Canada, Research Branch, Technical Bulletin 1998-9E. http://sis.agr.gc.ca/cansis/publications/ecostrat/provDescriptions/mbteee/mbteee_report.pdf

Society for Range Management [SRM]. 1998. Glossary of terms used in range management, fourth edition. Edited by the Glossary Update Task Group, Thomas E. Bedell, Chairman.

Symstad, A.J. and Jonas, J.L. 2011. Incorporating biodiversity into rangeland health: Plant species - richness and diversity in the Great Plains grasslands. Rangeland Ecology & Management **64**(6):555-572.

Tallowin, J.R.B., Rook, A.J., and Rutter, S.M. 2005. Impact of grazing management on biodiversity of grasslands. Animal Science **81**(2):193-198.

Thorpe, J. 2014. Rangeland classification for Agri-Manitoba. Prepared for Manitoba Forage and Grassland Association. Saskatchewan Research Council Pub. No. 12870-1E14.

Thorpe, J. 2014. Saskatchewan Rangeland Ecosystems, Publication 5: Communities on the Sand and Sandy Loam Ecosites. Version 2. Saskatchewan Prairie Conservation Action Plan. Saskatchewan Research Council Pub. No. 11881-5E14.

Thorpe, J. 2014. Saskatchewan Rangeland Ecosystems, Publication 9: Communities on the Dunes Ecosite. Version 2. Saskatchewan Prairie Conservation Action Plan. Saskatchewan Research Council Pub. No. 11881-9E14.

Thorpe, J. 2017. Ecosites of Southwest Manitoba [map]. MFGA. http://mfga.net/projects/current-projects/manitoba-ecosite-and-rangeland-health-initiative/

Vujnovic, K., Wein, R., and Dale, M.R.T. 2000. Factors determining the centrifugal organization of remnant Festuca grassland communities in Alberta. Journal of Vegetation Science **11**:127-134.

Widenmaier, K.J. and Strong, W.L. 2010. Tree and forest encroachment into fescue grasslands on the Cypress Hills plateau, southeast Alberta, Canada. Forest ecology and management **259**(10):1870-1879.

Willms, W.D., McGinn, S.M., and Dormaar, J.F. 1993. Influence of litter on herbage production in the Mixed Prairie. Journal of Range Management **46**(4):320-324.

Willms, W.D., Smoliak, S., and Bailey, A.W. 1986. Herbage production following litter removal on Alberta native grasslands. Journal of Range Management **39**(6):536-540.

Willms, W.D., Smoliak, S., and Dormaar, J.F. 1985. Effects of stocking rate on a rough fescue grassland vegetation. Journal of Range Management **38**(3):220-225.

Wilson, S.D. and Belcher, J.W. 1989. Plant and bird communities of native prairie and introduced Eurasian vegetation in Manitoba, Canada. Conservation Biology **3**(1): 39-44.

Young, J. E., Sánchez-Azofeifa, G. A., Hannon, S. J. and Chapman, R. 2006. Trends in land cover change and isolation of protected areas at the interface of the southern boreal mixedwood and aspen parkland in Alberta, Canada. Forest Ecology and Management **230**(1):151-161.

APPENDIX A

GLOSSARY OF ECOLOGICAL AND LAND MANAGEMENT TERMS

Definitions adapted from the *Glossary of terms used in range management* (Society for Range Management 1998), with additions from *Range Plan Development: A Practical Guide to Planning for Management and Improvement of Saskatchewan Rangeland* (Abouguendia 1990), and the *Draft Manitoba Range and Pasture Health Assessment Workbook for Native Grassland, Tame Pasture, and Forested Rangeland* (Manitoba Forage and Grassland Association 2017).

Browse. (n.) The parts of shrubs, woody vines and trees available for animal consumption. (v.) To search for or consume browse.

Cover. (1) The plant or plant parts, living or dead, on the surface of the ground. Vegetative cover or herbage cover is composed of living plants and litter cover of dead parts of plants. Syn. foliar cover (2) The area of ground covered by plants of one or more species.

Climax. (1) The final or stable biotic community in a successional series; it is self-perpetuating and in equilibrium with the physical habitat. (2) the assumed end point in succession.

Decadent. An inferior condition or state; deteriorated or decay. Term typically applied forests (like aspen) to indicate maturity. Mature forests are typically distinguished from younger forest stands due to their differences in forage availability and health, as older stands are susceptible to degradation or replacement by conifers (Jones et al. 2005).

Ecological functions. In the context of range health assessment guide are net primary production, soil/site stability, capture and slow release of water, nutrient and energy cycling and plant species diversity.

Ecological processes. Include the water cycle (the capture, storage, and redistribution of precipitation), energy flow (conversion of sunlight to plant and animal matter), and nutrient cycle (the cycle of nutrients through the physical and biotic components of the environment). Ecological processes functioning within a normal range of variation will support specific plant and animal communities.

Ecological status. Degree of similarity between the present plant community and the reference plant community.

Ecosite. Distinctive kind of land with specific physical characteristics (e.g. available moisture, soil texture and chemistry) that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation.

Foliar cover. The percentage of ground covered by the vertical projection of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded. Foliar cover is always less than canopy cover; either may exceed 100%. Syn. Cover

Forage. (n.) Plant biomass which is available and may provide food for grazing animals or be harvested for feeding. This includes palatable herbaceous plants and typically the current annual growth of woody plants (browse). (v.) To search for or consume forage. cf. (v.) browse, graze.

Forb(s). Any broad-leafed herbaceous plant other than those in the Poaceae, Cyperaceae and Juncaceae families.

Graminoid. Grass or grass-like plant, such as *Poa*, *Carex* and *Juncus* species.

Heavy grazing. A comparative term which indicates that the stocking rate of an area is relatively greater than that of other areas. Often erroneously used to mean overuse.

Indicators (of range and pasture health). Components of the ecosystem whose characteristics are used as an index that would otherwise be too difficult, inconvenient or expensive to measure. To illustrate, litter is an indicator of hydrologic functioning and its characteristics indexed to complete the health assessment is the amount of litter present at the site.

Plant community. Any assemblage of plants occurring and interacting together at any point in time, regardless of successional status. A unit of vegetation.

Plant responses. There are three possible species-specific responses to abiotic/biotic influence or management practice (any kind of disturbance but generally used in reference to continuous and heavy grazing) (see Appendix B for a detailed species list):

> **Decreaser.** For a given plant community, those species that decrease in amount as a result of a specific abiotic/biotic influence or management practice; generally used with reference to long term heavy grazing pressure. Examples include plains rough fescue, big bluestem, western wheatgrass, American vetchling, and Saskatoon berry.
>
> **Increaser.** For a given plant community, those species that increase in amount as a result of a specific abiotic/biotic influence or management practice; generally used with reference to long term heavy grazing pressure. Examples include blue grama grass, sage, upland sedges, goldenrod, and wolf willow.
>
> **Exotic invaders**. Plant species that are alien to the site but have been introduced by seeding or have invaded; some of them increase in amount as a result of a specific abiotic/biotic influence or management practice. Examples include Kentucky bluegrass, smooth brome, dandelion, and lamb's quarters.

Potential plant community. One of usually several plant communities that may become established on an ecological site under the present environmental conditions, either with or without interference by man.

Rangeland. Land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangeland includes natural grasslands, savannas, shrublands, many deserts, tundras, alpine communities, marshes and meadows.

Rangeland health. The degree to which the integrity of the soil, the vegetation, the water, and air as well as the ecological processes of the rangeland ecosystem is balanced and sustained. Integrity is defined as: Maintenance of the structure and functional attributes characteristic of a particular locale, including normal variability.

Reference plant community (RPC) is interchangeable with the term **potential natural community** and is the plant community that would become established on an ecosite under current climatic conditions, either with or without interference by man.

Resilience. The ability of rangelands and pastures to respond to disturbance by resisting damage and recovering quickly.

Retrogression. A historical term used by some ecologists to mean succession in reverse. According to Clements (1916), however, retrogression is synonymous with destruction and denudation of a plant community.

Succession. Gradual replacement of one plant community by another over time.

Seral stages. Individual steps along a successional pathway. These can be limited by environmental conditions such as soil types and climate – for example dry, sandy soils will limit tree and shrub growth even in the absence of fire or grazing. Seral stages begin at the pioneer stage of **early seral**, and progress upward in succession to **mid-seral**, then late seral and finally **reference plant community** or **climax**.

Stable state. The condition of little or no perceived change in a plant community that is in relative equilibrium with existing environmental conditions.

State and transition (S&T) diagram. Depicts the complex nature of plant community dynamics under the influences of disturbance, grazing management, idleness, or invasion (by exotic or woody species). Acknowledges that plant communities shift along non-linear pathways and thresholds can be crossed resulting in new stable states.

Stocking rate. A measure of forage demand requiring an element of time and area. Describes how many animal units graze in a specific amount of time over a specific amount of area. Standardized units are Animal Unit Months per Hectare (AUM/ha), or Animal Unit Days per Hectare (AUD/ha). An Animal Unit equates to a 1000 lb cow with or without suckling calf (i.e. a 1400 lb cow is often considered to be 1.4 AU).

Successional pathway. Describes the predictable pathway of change in the plant community as it recovers from disturbance over time.

Threshold. When a plant community cannot return to a previous state without significant intervention. A threshold is passed when a plant community enters a new stable state (e.g. grassland, forest, eroded/degraded community).

APPENDIX B

LIST OF DECREASERS, INCREASERS, AND EXOTIC INVADERS

Scientific Name	Common Name(s)	Grazing Response[1]
GRASSES AND GRASSLIKE PLANTS		
Achnatherum richardsonii	Richardson's needlegrass	Decreaser
Agropyron cristatum	Crested wheatgrass	Exotic/Invader
Agrostis scabra	(Rough) hair grass	Exotic/Invader
Agrostis stolonifera	Creeping bentgrass	Exotic/Invader
Andropogon gerardii	Big bluestem	Decreaser
Andropogon hallii	Sand bluestem	Decreaser
Anthoxanthum hirtum	Sweet grass	Increaser
Aristida purpurea	Red threeawn	Increaser
Avenula hookeri	Hooker's oatgrass	Decreaser
Beckmannia syzigachne	Slough grass	Increaser
Bouteloua curtipendula	Sideoats grama	Decreaser
Bouteloua gracilis	Blue grama	Increaser
Bromus ciliatus	Fringed brome	Decreaser
Bromus inermis	Smooth brome	Exotic/Invader
Bromus pumpellianus	Northern awnless brome	Decreaser
Calamagrostis canadensis	Canada reed grass	Increaser
Calamagrostis montanensis	Plains reed grass	Increaser/Decreaser [2]
Calamagrostis stricta ssp. *stricta*	Narrow reed grass	Decreaser
Calamagrostis stricta ssp. *inexpansa*	Northern reed grass	Decreaser
Calamovilfa longifolia	Sand grass, Prairie sandreed	Increaser/Decreaser [2]
Carex atherodes	Awned sedge	Decreaser
Carex duriuscula	Low sedge	Increaser
Carex filifolia	Thread-leaved sedge	Increaser
Carex pensylvanica	Pen or sun-loving sedge	Increaser
Carex praegracilis	Graceful sedge	Decreaser
Carex rostrata	Beaked sedge	Decreaser
Danthonia intermedia	Timber oatgrass, Intermediate oat grass	Increaser
Danthonia spicata	Poverty oatgrass	Increaser
Deschampsia cespitosa	Tufted hair grass	Decreaser
Dichanthelium spp.	Panic grass	Increaser/Decreaser [2]
Dichanthelium wilcoxianum	Wilcox panic grass	Decreaser
Distichlis spicata	Saltgrass	Increaser
Elymus canadensis	Canada wild rye	Decreaser
Elymus lanceolatus	Northern wheatgrass	Increaser
Elymus trachycaulus ssp. *trachycaulus*	Slender wheatgrass	Increaser/Decreaser [2]
Elymus trachycaulus ssp. *subecundus*	Bearded wheatgrass, Awned wheatgrass	Decreaser
Festuca hallii	Plains rough fescue	Decreaser

Scientific Name	Common Name(s)	Grazing Response[1]
Festuca ovina	Sheep fescue	Increaser
Glyceria grandis	Tall manna grass	Decreaser
Glyceria striata	Fowl manna grass	Increaser/Decreaser [2]
Hesperostipa comata	Needle and thread	Increaser/Decreaser [2]
Hesperostipa curtiseta	Western porcupine grass	Increaser/Decreaser [2]
Hesperostipa spartea	Porcupine grass	Decreaser
Hordeum jubatum	Foxtail barley	Increaser
Juncus balticus	Baltic rush	Increaser
Koeleria macrantha	Prairie junegrass	Decreaser
Leymus innovatus	Hairy wildrye	Increaser
Maianthemum stellatum	Solomon's seal, Star-flowered false Solomon's seal	Increaser/Decreaser [2]
Muhlenbergia cuspidata	Plains muhly	Increaser/Decreaser [2]
Muhlenbergia richardsonis	Mat muhly	Increaser
Nassella viridula	Green needlegrass	Decreaser
Opuntia, Escobaria spp.	Cactus	Increaser
Oryzopsis asperifolia	Aspen rice grass, White-grained rice grass	Decreaser
Panicum virgatum	Switch grass	Decreaser
Pascopyrum smithii	Western wheatgrass	Decreaser
Piptatherum pungens	Northern ricegrass	Decreaser
Poa palustris	Fowl blue grass	Decreaser
Poa pratensis	Kentucky bluegrass	Exotic/Invader
Puccinellia nuttalliana	Nuttall alkali grass	Decreaser
Schizachne purpurascens	Purple oat grass	Decreaser
Schizachyium scoparium	Little bluestem	Increaser/Decreaser [2]
Scholochloa festucacea	Rivergrass, Spangletop	Decreaser
Spartina gracilis	Alkali cordgrass	Increaser
Spartina pectinata	Prairie cordgrass	Decreaser
Sporobolus cryptandrus	Sand dropseed	Increaser/Decreaser [2]
Sporobolus heterolepis	Prairie dropseed	Decreaser
FORBS		
Achillea millefolium	Woolly yarrow, Western yarrow	Increaser
Anemone patens	Crocus	Increaser
Antennaria spp.	Everlasting	Increaser
Apocynum androsaemifolium	Spreading dogbane	Decreaser
Aralia nudicaulis	Wild sarsaparilla	Decreaser
Artemisia frigida	Fringed sage	Increaser
Artemisia ludoviciana	Prairie sage	Increaser
Astragalus spp.	Milkvetches	Increaser/Decreaser [2]
Chenopodium album	Lamb's quarters	Exotic/Invader
Dalea purpurea	Purple prairie clover	Decreaser
Gaillardia aristata	Gaillardia, Blanketflower	Increaser

Scientific Name	Common Name(s)	Grazing Response[1]
Galium boreale	Northern bedstraw	Increaser
Geum aleppicum	Yellow avens	Increaser
Geum triflorum	Three-flowered avens	Increaser
Glycyrrhiza lepidota	Wild licorice	Increaser
Grindelia squarrosa	Gumweed	Increaser
Gutierrezia sarothrae	Broomweed	Increaser
Hedysarum spp.	Sweet-broom	Increaser
Heterotheca villosa	Golden aster	Increaser
Lathyrus ochroleucus	Cream-colored vetchling	Decreaser
Lathyrus venosus	Wild peavine, Purple peavine	Decreaser
Lepidium densiflorum	Common peppergrass	Exotic/Invader
Liatris punctata	Dotted blazing star	Decreaser
Lupinus argenteus	Silky or silvery lupine	Increaser
Lygodesmia juncea	Skeleton weed	Increaser
Mertensia paniculata	Tall lungwort	Decreaser
Oxytropis spp.	Locoweeds	Increaser
Penstemon spp.	Beard tongue	Increaser
Petasites spp.	Coltsfoot	Decreaser
Phlox hoodii	Moss phlox	Increaser
Ratibida columnifera	Long-headed coneflower	Increaser
Selaginella densa	Club moss	Increaser
Solidago canadensis	Graceful goldenrod	Increaser
Solidago missouriensis	Low goldenrod	Increaser
Sphaeralcea coccinea	Scarlet mallow	Increaser
Symphyotrichum falcatum	White prairie aster	Increaser
Symphyotrichum laeve	Smooth aster	Increaser
Taraxacum officinale	Dandelion	Exotic/Invader
Thalictrum venulosum	Meadow rue	Increaser
Thermopsis rhombifolia	Golden bean	Increaser
Tragopogon dubius	Goatbeard	Exotic/Invader
Trifolium spp.	Clover	Exotic/Invader
Vicia americana	Wild Vetch	Decreaser
Vicia spp.	Vetches	Decreaser
Zigadenus venenosus	Death camas	Increaser
SHRUBS AND TREES		
Alnus viridis	Green alder	Increaser
Amelanchier alnifolia	Saskatoon	Decreaser
Artemisia cana	Silver sage	Increaser
Artemisia frigida	Fringed sage	Increaser
Atriplex gardneri	Nuttall's saltbush	Decreaser
Betula papyrifera	Paper birch	Decreaser

Scientific Name	Common Name(s)	Grazing Response[1]
Cornus sericea ssp. sericea	Red-osier dogwood	Decreaser
Corylus cornuta	Beaked hazel	Increaser
Crataegus chrysocarpa var. *subrotundifolia*	Round-leaved hawthorn	Increaser
Dasiphora fruticosa	Shrubby cinquefoil	Increaser
Elaeagnus commutata	Wolf willow	Increaser
Juniperus horizontalis	Creeping juniper	Increaser
Krascheninnikovia lanata	Winterfat	Decreaser
Lonicera dioica	Twining honeysuckle	Decreaser
Populus balsamifera	Balsam poplar	Increaser
Populus tremuloides	Trembling aspen, Aspen poplar	Increaser
Prunus pensylvanica	Pin cherry	Decreaser
Prunus pumila	Sand cherry	Decreaser
Prunus virginiana	Chokecherry	Decreaser
Quercus macrocarpa	Bur oak	Increaser
Ribes oxyacanthoides	Gooseberry	Increaser
Ribes spp.	Currant	Increaser
Rosa spp.	Rose	Increaser
Rubus idaeus	Raspberry	Increaser
Salix spp.	Willow	Increaser/Decreaser [2]
Shepherdia canadensis	Canada buffaloberry	Decreaser
Spiraea alba	Meadowsweet	Decreaser
Symphoricarpos albus	Snowberry	Increaser
Symphoricarpos occidentalis	Western snowberry	Increaser
Vaccinium oxycoccos	Low bush-cranberry	Decreaser
Viburnum lentago	Nannyberry	Decreaser
Viburnum opulus	High-bush cranberry	Decreaser

1- From Abouguendia. 1990.; USDA Natural Resource Conservation Service (NRCS). 1984., Prairie Farm Rehabilitation Administration (PFRA). 2000-2013.

2- Different sources suggest different grazing responses

APPENDIX C

ORDINATIONS OF PLANT GRASSLAND PLANT COMMUNITIES BY ECOSITE

Interpretation of NMDS (non-metric multidimensional scaling) Ordinations

We have presented our ordination diagrams as supplemental information. Ordination was used post-cluster analysis to understand why the different sample units (plots or transects) within our data grouped together and to speculate on how the groups are different from one another.

Multi-variate data are multi-dimensional (i.e. having 3 or more gradients among variables). Picture a simple scatterplot of two variables (x and y) that show a trend on two axes, and then add a third variable (z) with a third trend shown with third axis (a 3-dimensional graph). It is virtually impossible to visualize a fourth variable's axis, much less the dozens of possible axes in our plant community data, each depicting different patterns of variability among the sample units (i.e. transects or plots). Ordination diagrams simplify and depict our sampling unit data into fewer dimensions (in our case, 2) that maximize the proportion of variance among sampling units that can be explained using species composition and abundance variables (Legendre and Legendre 2012).

Ordination diagrams allow us to identify patterns such as similarity [in plant species composition] or how differences among sampling units relate to factors such as overall plant community characteristics (e.g. successional index or proportion of exotic species), environmental variables, and structure (e.g. bare soil, plant litter cover). In our case, points on the diagram are (sampling units). Those points that are closer to each other have more similarity in species composition than those that are further apart. Similarity is calculated using a similarity index. In this case, a Bray-Curtis index was used. Arrows appear in the ordination diagram for statistically significant gradients ($p \leq 0.05$). For example, an arrow pointing towards 'Exotic Poa' indicates a gradient of plant communities from lesser to greater relative exotic bluegrass abundance. Species names were also plotted in the diagram if significant ($p \leq 0.01$ or 0.001 for clarity), and they too can be interpreted like arrows where they indicate a gradient towards greater abundance of that species. Finally, labels representing assigned plant communities (e.g. LM1, LM2, etc. for the Loam ecosite) are plotted at the centroid of that plant community's scattered sample unit points.

Stress is an index of the amount of variation in the data that is not explained by the prescribed number of dimensions in current ordination (it is difficult to force data that naturally vary along numerous axes into only two). If we allow our ordinations to plot samples along an additional axis, the stress would decrease.

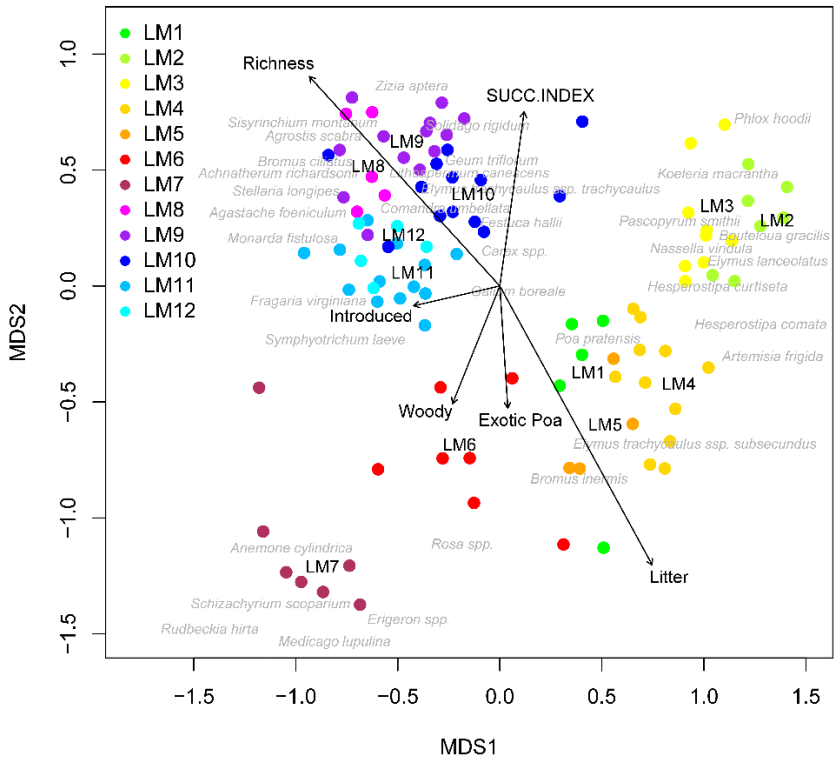


Figure A1. NMDS of plant communities on the **Loam** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.192).

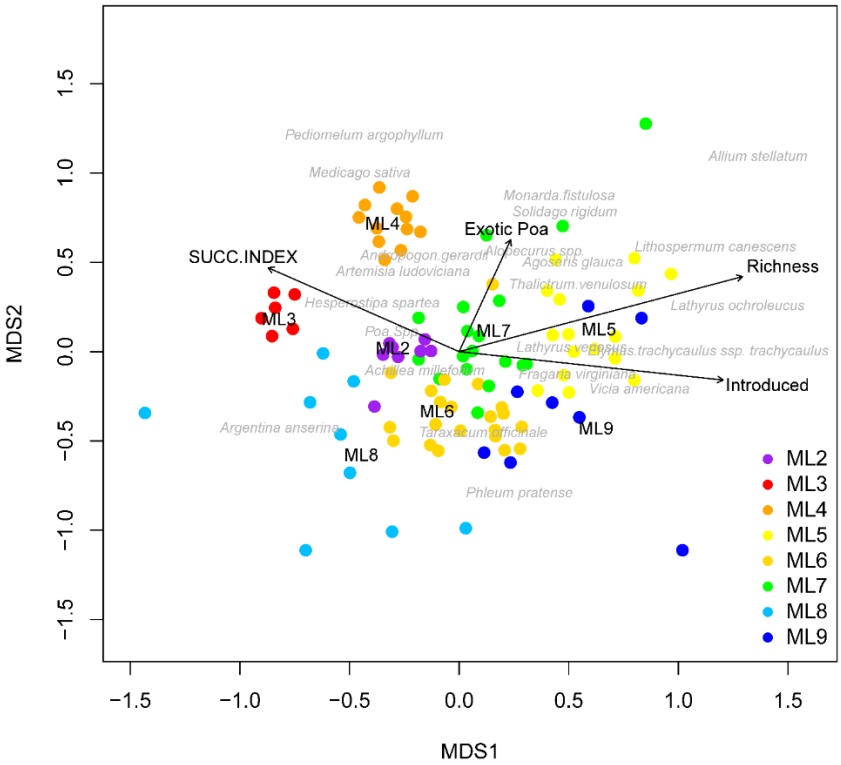


Figure A2. NMDS of plant communities on the **Moist Loam** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.250).

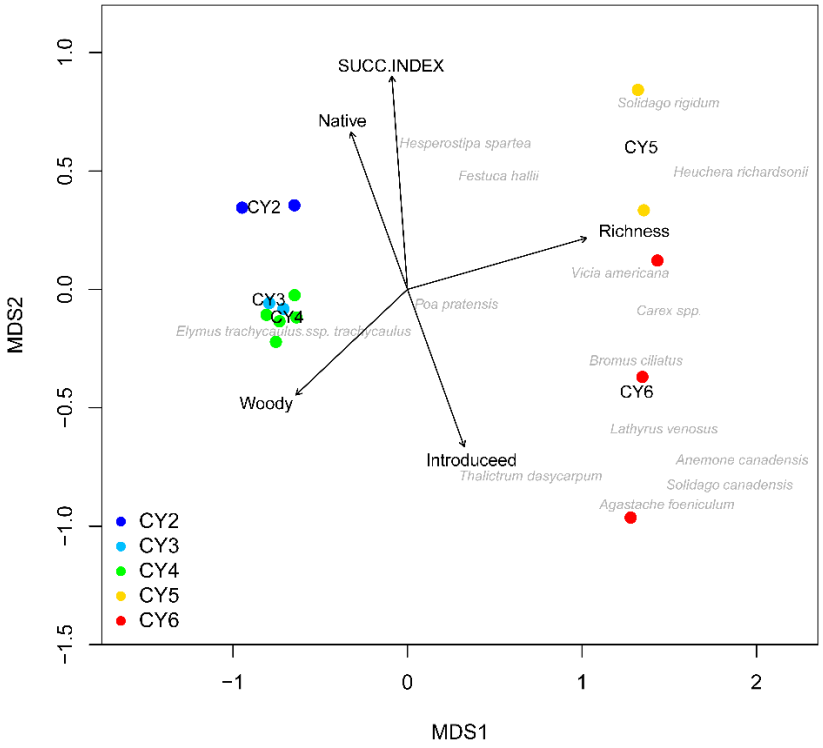


Figure A3. NMDS of plant communities on the **Clay** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.047).

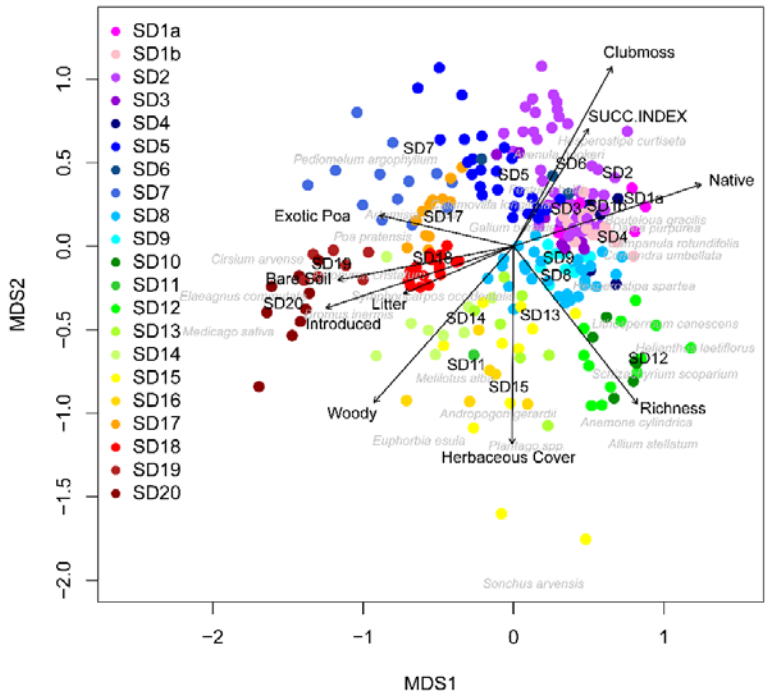


Figure A4. NMDS of plant communities on the **Sand** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.232).

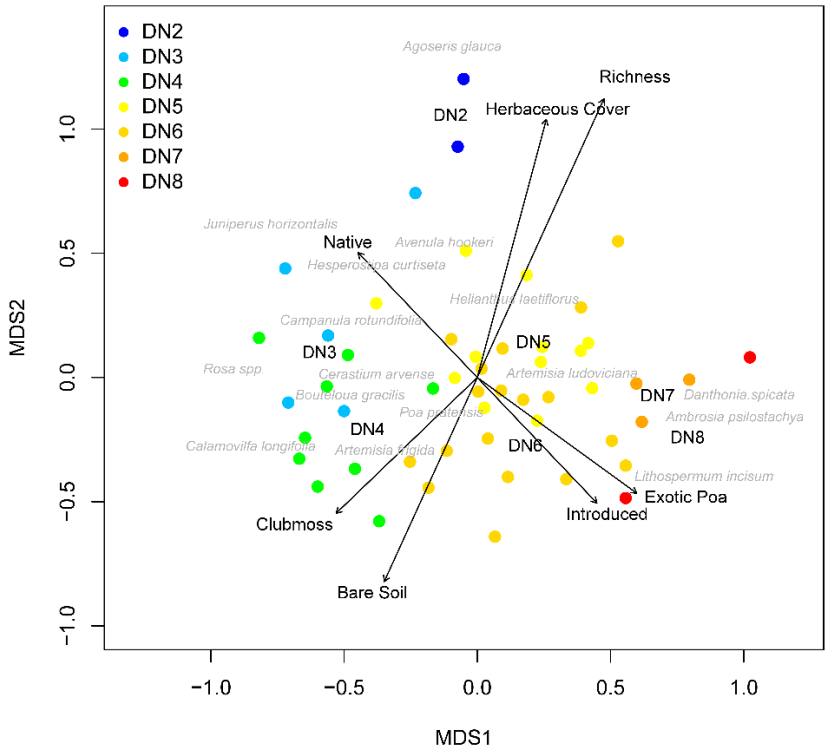


Figure A5. NMDS of plant communities on the **Dunes** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.217).

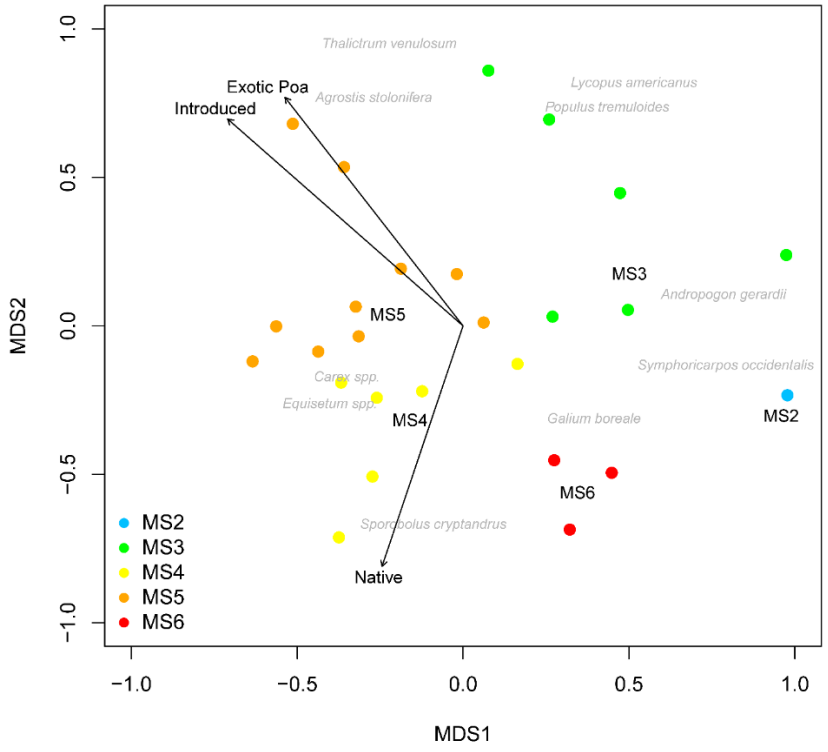


Figure A6. NMDS of plant communities on the **Moist Sand** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.224).

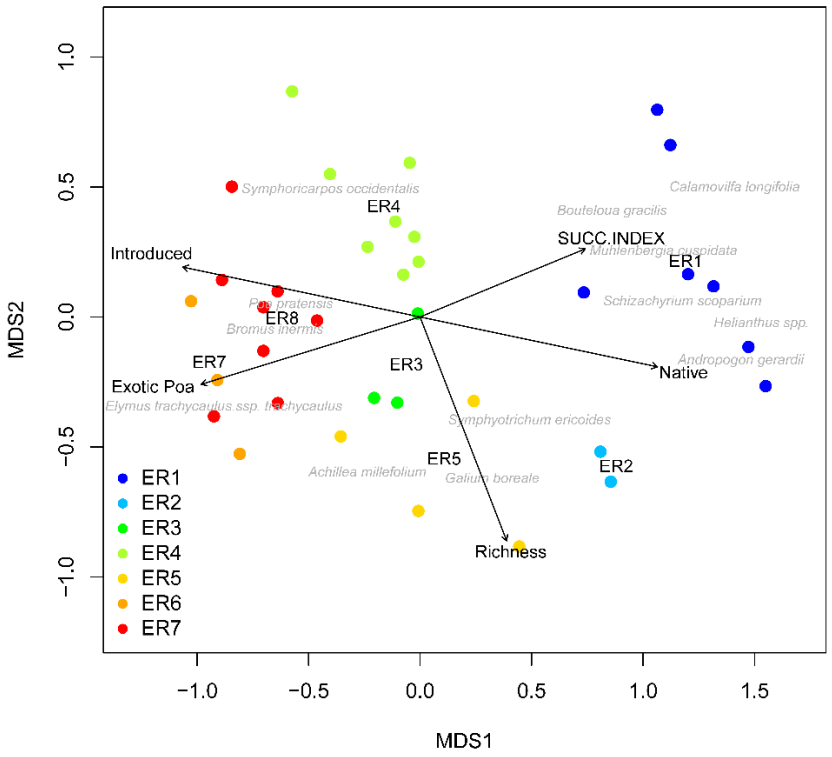


Figure A7. NMDS of plant communities on the **Eroded Slopes** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.166).

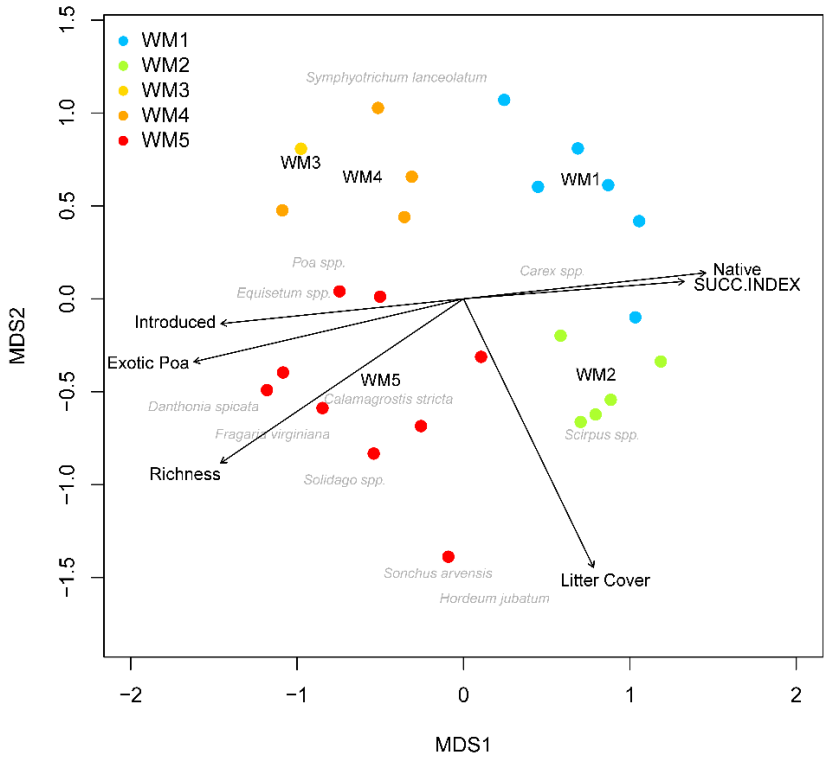


Figure A8. NMDS of plant communities on the **Wet Meadow** ecosite (axes = 2, distance = Bray-Curtis, stress = 0.204).