USDA Natural Resources Conservation Service

Ecological site R056BY096MN
Subirrigated Sands

Last updated: 9/04/2024
Accessed: 11/24/2024

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 056B–Glacial Lake Agassiz, Tallgrass Aspen Parklands

MLRA 56B is part of the glacial Lake Agassiz basin, which formed as the lake receded. Most of the area is glaciolacustrine sediments overlying till. This MLRA is entirely in Minnesota and makes up about 4,664 square miles (12,079 square kilometers). It is bordered by beaches and a lake plain on the west (MLRA 56A), by a till plain on the south (MLRA 102A), and by a lake plain and till plain on the east (MLRA 88). (United States Department of Agriculture, Agriculture Handbook 296)

Classification relationships

Level IV Ecoregions of the Conterminous United States: 48a Glacial Lake Agassiz Basin; 48b Beach Ridges and Sand Deltas; and 48d Lake Agassiz Plains.

MLRA 56B (United States Department of Agriculture, Agriculture Handbook 296, 2022).

Ecological site concept

The Subirrigated Sands ecological site is primarily located on till-floored lake plains, flats and lake plains a few areas also occur on glacial lake beaches. Slopes range 0 to 6 percent. The common features of soils in this site are coarse textures to a depth of greater than 20 inches and a seasonal water table. The soils are moderately to very deep. Surface and subsoil textures typically are loamy fine sand, fine sand or loamy sand; these textures do not form a ribbon. Soil on this site is moderately well drained; redoximorphic features are deeper than 24 inches.

Associated sites

R056BY087MN	**Limy Subirrigated** This site occurs on flats that are slightly lower on the landscape. The soil is highly calcareous in the upper part of the subsoil (within a depth of 16 inches) and has redoximorphic features at a depth of 18 to 30 inches. All textures are included in this site.
R056BY095MN	**Subirrigated** This site occurs in swales and blow-outs. It has redoximorphic features at a depth of 18 to 30 inches. All textures are included in this site.
R056BY104MN	**Choppy Sands** This site occurs on dunes with slopes >15 percent. The surface and subsoil layers do not form a ribbon.
R056BY090MN	**Sands** This site occurs higher on the landscape. It is sand or loamy sand (fine to coarse sands) within a depth of 10 inches; the subsoil soil does not form a ribbon. Redoximorphic features, where present, are deeper than 40 inches.

R056BY102MN	**Wet Meadow** This site occurs on similar landscape positions. The soil does not have a claypan layer. E.C. is <8. All textures are included in this site.

Similar sites

R056BY090MN	**Sands** This site occurs higher on the landscape. It is sand or loamy sand (fine to coarse sands) within a depth of 10 inches; the subsoil soil does not form a ribbon. Redoximorphic features, where present, are deeper than 40 inches.
R056BY095MN	**Subirrigated** This site occurs in swales and blow-outs. It has redoximorphic features at a depth of 18 to 30 inches. All textures are included in this site..

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Andropogon gerardii* (2) *Calamovilfa longifolia*

Physiographic features

This site typically occurs on uplands – till-floored lake plains, flats, and lake plains a few areas also occur on glacial lake beaches. Slopes range from 0 to 6 percent.

Table 2. Representative physiographic features

Landforms	(1) Till-floored lake plain (2) Flat (3) Lake plain (4) Beach
Runoff class	Very low to low
Flooding frequency	None
Ponding frequency	None
Elevation	229–451 m
Slope	0–6%
Ponding depth	0 cm
Water table depth	61–152 cm
Aspect	Aspect is not a significant factor

Climatic features

About 70 percent of the rainfall comes from high-intensity, convective thunderstorms during the growing season. Winter precipitation accounts for about 15 percent of the annual precipitation.

Table 3. Representative climatic features

Frost-free period (characteristic range)	103-108 days
Freeze-free period (characteristic range)	133-136 days
Precipitation total (characteristic range)	559-584 mm
Frost-free period (actual range)	102-110 days
Freeze-free period (actual range)	132-137 days

Precipitation total (actual range)	559-610 mm
Frost-free period (average)	106 days
Freeze-free period (average)	135 days
Precipitation total (average)	584 mm

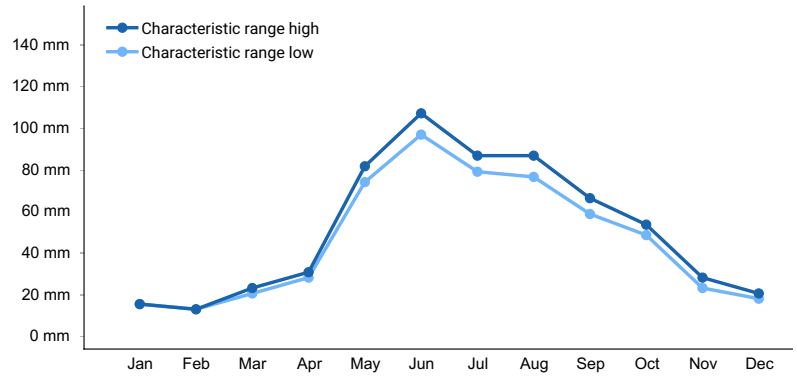


Figure 1. Monthly precipitation range

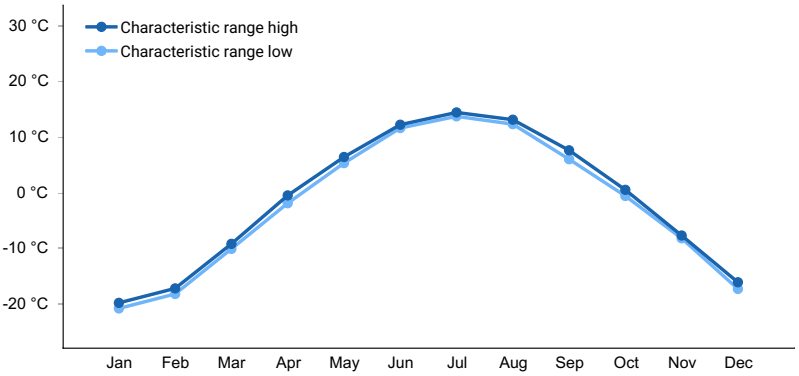


Figure 2. Monthly minimum temperature range

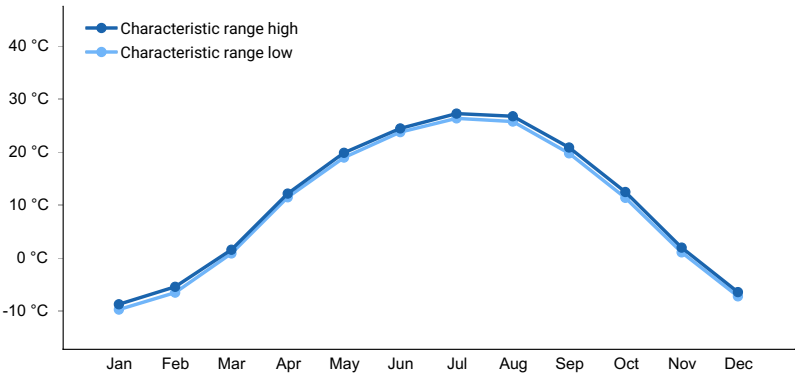


Figure 3. Monthly maximum temperature range

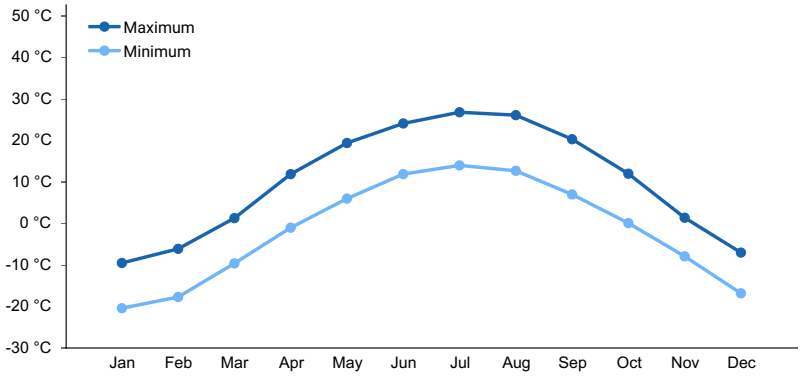


Figure 4. Monthly average minimum and maximum temperature

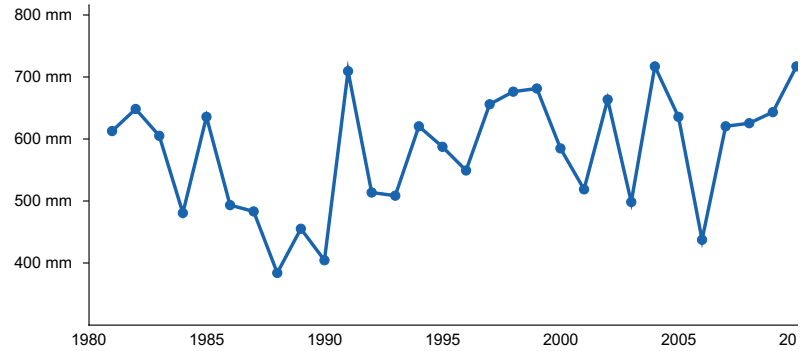


Figure 5. Annual precipitation pattern

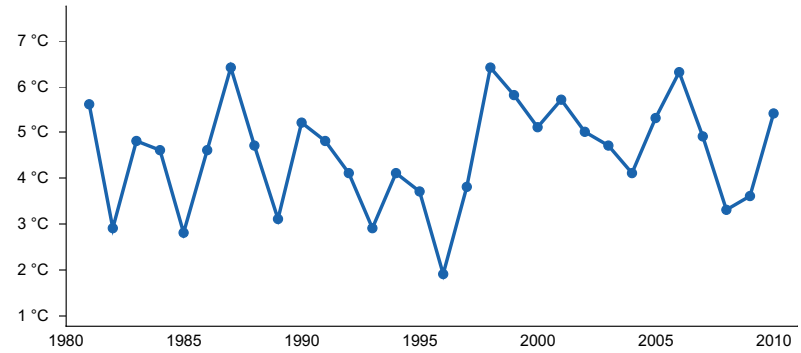


Figure 6. Annual average temperature pattern

Climate stations used

- (1) GOODRIDGE 12 NNW [USW00004994], Grygla, MN
- (2) AGASSIZ REFUGE [USC00210050], Grygla, MN
- (3) RED LAKE FALLS [USC00216787], Red Lake Falls, MN
- (4) CROOKSTON NW EXP STN [USC00211891], Crookston, MN
- (5) HALLOCK [USC00213455], Hallock, MN

Influencing water features

Under normal climatic conditions, this site receives additional water from a seasonal high water table. The duration of the water table can be prolonged in some soils due a loamy substratum layer which perches some water in the lower root zone and also contributes to lateral flow from surrounding uplands. During the growing season, water table depths typically are 3 to 5 feet during April through June; however, it can be as shallow as 2 feet in early spring. It commonly lowers to 4 to 6 feet during mid-summer through autumn. Surface infiltration is rapid or very rapid. Saturated hydraulic conductivity through the profile typically is high. In soils with a loamy or clayey substratum, the saturated hydraulic conductivity is moderately high to moderately low in that layer; this slows percolation and can prolong subirrigation in spring and early summer. Water loss is primarily through evapotranspiration. During mid-summer, percolation below the root zone may also occur.

Due to the low relief landscape that typically surrounds this site, additional water received as runoff from adjacent uplands is not a major factor in the soil/hydrology/plant relationship

Wetland description

Not Applicable.

Soil features

Most soils associated with Subirrigated Sands ES were formed in sandy glaciolacustrine deposits; in some areas each of these parent materials have an underlying parent material, either of till or of glaciolacustrine sediments containing more silt and clay.

The common features of soils in this site are coarse textures to a depth of greater than 20 inches and a seasonal water table which is moderately high contributing additional water for transpiration. Surface and subsoil textures typically are loamy fine sand, fine sand or loamy sand; these textures do not form a ribbon. Fine sandy loam surface textures are allowable if <10 inches thick. The soils are moderately well drained – redoximorphic features are visible at a depth of 2 to 3.5 feet. These soils are moderately to very deep. Most soils in this site have less than 10 percent gravel. Soil reaction typically is slightly acid to slightly alkaline (pH 6.1 to 7.8).

This site should show slight to no evidence of rills, wind-scoured areas, or pedestaled plants. No water flow paths are seen on this site. The soil surface is stable and intact. Sub-surface soil layers are non-restrictive to water movement and root penetration. These soils are susceptible to wind erosion. Loss of the soil surface layer can result in a shift in species composition and/or production.

Major soil series correlated to the Subirrigated Sands site are: Aylmer, Eckvoll, Enstrom, Foldahl, Hilaire, Poppleton, and Rushlake.

Access Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx) for specific local soils information.

Permeability note: The permeability class of the Eckvoll, Enstrom, Foldahl, and Hilaire soils is rapid or very rapid in the upper part and moderate to slow in the lower part. Depth to the layer of reduced permeability is 20 to 40 inches in these soils.

Table 4. Representative soil features

Parent material	(1) Glaciolacustrine deposits (2) Till
Surface texture	(1) Loamy fine sand (2) Fine sandy loam (3) Fine sand (4) Loamy sand
Drainage class	Moderately well drained
Permeability class	Moderately slow to rapid
Depth to restrictive layer	99–203 cm
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	8.38–14.22 cm
Soil reaction (1:1 water) (0-25.4cm)	6.1–7.8

Subsurface fragment volume <=3" (0-152.4cm)	0–10%
Subsurface fragment volume >3" (0-152.4cm)	0–2%

Ecological dynamics

Ecological Dynamics of the Site:

This ecological site description is based on nonequilibrium ecology and resilience theory and utilizes a State-and-Transition Model (STM) diagram to organize and communicate information about ecosystem change as a basis for management. The ecological dynamics characterized by the STM diagram reflect how changes in ecological drivers, feedback mechanisms, and controlling variables can maintain or induce changes in plant community composition (phases and/or states). The application of various management actions, coupled with weather variables, impact the ecological processes which influence the competitive interactions thereby maintaining or alter plant community structure.

Prior to European influence, the historical disturbance regime for MLRA 56 included frequent fires, both anthropogenic and natural in origin. Most fires, however, were anthropogenic fires set by Native Americans. Native Americans set fires in all months except perhaps January. These fires occurred in two peak periods, one from March-May with the peak in April and another from July-November with the peak occurring in October. Most of these fires were scattered and of small extent and duration. The grazing history would have involved grazing and browsing by large herbivores such as American bison, elk, and whitetail deer. Herbivory by small mammals, insects, nematodes and other invertebrates are also important factors influencing the production and composition of the communities. Grazing and fire interaction, particularly when coupled with drought events, influenced the dynamics discussed and displayed in the following state and transition diagram and descriptions.

Following European influence, this ecological site generally has had a history of grazing by domestic livestock, particularly cattle, which along with other related activities (e.g. fencing, water development, fire suppression) has changed the disturbance regime of the site. Changes will occur in the plant communities due to these and other factors.

Weather fluctuations coupled with managerial factors may lead to changes in the plant communities, and may, under adverse impacts, result in a slow decline in vegetative vigor and composition. However, under favorable conditions the botanical composition may resemble that prior to European influence.

Six vegetative states have been identified for the site (Reference, Native/Invaded, Wooded, Invaded, Go-Back, and cropland). Within each state one or more community phases have been identified. These community phases are named based on the more dominant and visually conspicuous species, and have been determined by study of historical documents, relict areas, scientific studies, and ecological aspects of plant species and plant communities. Transitional pathways and thresholds have been determined through similar methods.

State 1: Reference State represents the natural range of variability that dominated the dynamics of this ecological site prior to European influence. Dynamics of the state were largely determined by variations in climate and weather (e.g. drought) as well as that of fire (e.g. timing, frequency), and grazing by native herbivores (e.g. frequency, intensity, selectivity). Due to those variations, the Reference State is thought to have shifted temporally and spatially between two Plant Community Phases.

Presently the primary disturbances are due to the widespread introduction of exotic species, concentrated livestock grazing, lack of fire, and perhaps long-term non-use and no fire. Because of these changes (particularly the widespread occurrence of exotic species), as well as other environmental changes, the Reference State is considered to no longer exist. Thus, the presence of exotic species on the site precludes it from being placed in the Reference State. It must then be placed in one of the other states, most commonly State 2: Native/Invaded State (T1A).

State 2: Native/Invaded State: Colonization of the site by exotic species results in a transition from State 1: Reference State to State 2: Native/Invaded State (T1A). This transition was probably inevitable, and often resulted

from colonization by exotic cool-season grasses such as Kentucky bluegrass, smooth brome, crested wheatgrass, and/or quackgrass which have been particularly and consistently invasive under extended periods of no use and no fire. Other exotics such as Canada thistle and leafy spurge are also known to invade the site.
Three community phases have been identified for this state and are similar those of the Reference State but have now been invaded by exotic cool-season grasses. These exotic cool-season grasses can be expected to increase. As that increase occurs, plants more desirable to wildlife and livestock may decline. A decline in forb diversity can also be expected. Under non-use or minimal use management, mulch increases and may become a physical barrier to plant growth. It also changes the micro-climate near the soil surface and may alter infiltration, nutrient cycling, and biological activity near the soil surface. As a result, these factors coupled with shading cause desirable native plants to have increasing difficulty remaining viable and recruitment declines.

To slow or limit the invasion of these exotic grasses or other exotic plants, it is imperative that managerial options (e.g. prescribed grazing, prescribed burning) be carefully constructed and evaluated with respect to that objective. If management does not include measures to control or reduce these exotic plants, the transition to State 4: Invaded State should be expected (T2B). The threshold to this transition is reached when the exotic cool-season grasses exceed 30% of the plant community and native grasses represent less than 40% of the community. This state may also transition to State 3: Wooded State during extended periods of non-use (or very light grazing) and no fire (T2A).

State 3: Wooded State
This state historically existed as small patches of shrubs and perhaps trees scattered across the site when precipitation, fire frequency, and other factors enabled woody species to colonize or encroach on the site. This often resulted in a mosaic of patches of woody vegetation interspersed within the grass dominated vegetation. A marked increase in non-use management and active fire suppression since European influence has enabled this state to expand and become more widespread. One community phase has been identified and often results from extended periods of non-use (or very light grazing) and no fire (T2A, T4A).

Brush control can lead to State 4: Invaded State (T3A). Brush control can also lead to State 2: Native/Invaded State (R3A), however depending upon the native component a range planting may be necessary to complete the restoration.

State 4: Invaded State. The threshold for this state is reached when the exotic cool-season grasses exceed 30% of the plant community and native grasses represent less than 40% of the community. One plant community phase has been identified for this state.

The exotic cool-season grasses can be quite invasive and often form monotypic stands. As they increase, both forage quantity and quality of the annual production becomes increasingly restricted to late spring and early summer even though annual production may increase. Forb diversity often declines. Under non-use or minimal use management, mulch can increase and becomes a physical barrier to plant growth, altering nutrient cycling, infiltration, and soil biological activity. As such, desirable native plants become increasingly displaced.

Once the state is well established, prescribed burning and prescribed grazing techniques have been largely ineffective in suppressing or eliminating the exotic cool-season grasses even though some short-term reductions may appear successful. However, assuming there is an adequate component of native grasses to respond to treatments, a restoration pathway to State 2: Native/Invaded State (R4A) may be accomplished with the implementation of long-term prescribed grazing in conjunction with prescribed burning. This state may also transition to State 3: Wooded State during extended periods of non-use or very light grazing and no fire (T4A).

State 5: Go-Back State often results following cropland abandonment and consists of only one plant community phase. This weedy assemblage may include noxious weeds that need control. Over time, the exotic cool-season grasses Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass will likely predominate.

Initially, due to extensive bare ground and a preponderance of shallow rooted annual plants, infiltration is low and the potential for soil erosion is high. Plant species richness may be high, but overall diversity (i.e. equitability) is typically low, with the site dominated by a relatively small assemblage of species. Due to the lack of native perennials and other factors, restoring the site with the associated ecological processes is difficult. However, a successful range planting may result in something approaching State 2: Native/Invaded State (R5A). Following seeding, prescribed grazing, prescribed burning, haying, and the use of herbicides will generally be necessary to

achieve the desired result and control weeds, some of which may be noxious weeds. A failed range planting and/or secondary succession will lead to State 4: Invaded State (R5B).

State 6: Cropland State results from planting and production of annual crops. This plant community is most commonly associated with cropped fields. Soil conditions can be quite variable on the site, in part due to variations in the management/cropping history (e.g. development of tillage induced compaction, erosion, fertility, herbicide/pesticide carryover). Thus, soil conditions should be assessed when considering restoration techniques..

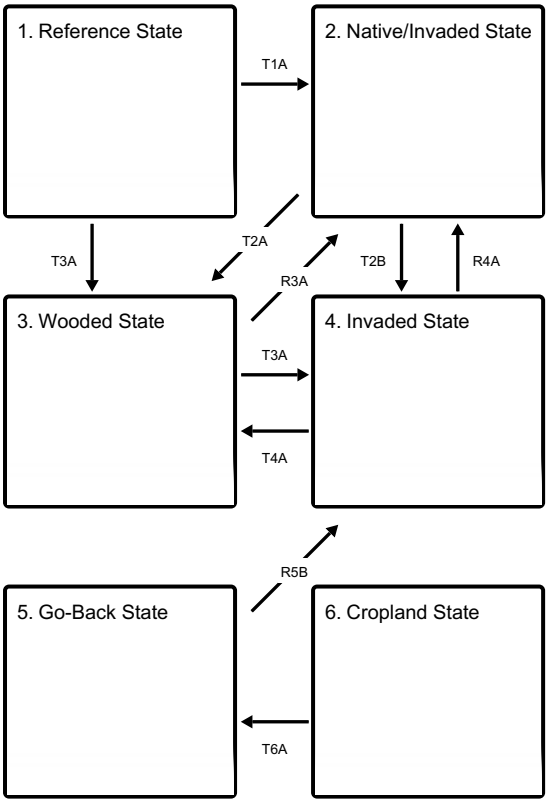
The following state and transition model diagram illustrates the common states, community phases, community pathways, transition and restoration pathways that can occur on the site. These are the most common plant community phases and states based on current knowledge and experience; changes may be made as more data are collected. Pathway narratives describing the site's ecological dynamics reference various management practices (e.g. prescribed grazing, prescribed fire, brush management, herbaceous weed treatment) which, if properly designed and implemented, will positively influence plant community competitive interactions. The design of these management practices will be site specific and should be developed by knowledgeable individuals, based upon management goals, a resource inventory, and supported by an ongoing monitoring protocol.

When the management goal is to maintain an existing plant community phase or restore to another phase within the same state, modification of existing management to ensure native species have the competitive advantage may be required. To restore a previous state, the application of two or more management practices in an ongoing manner will be required. Whether using prescribed grazing, prescribed burning, or a combination of both with or without additional practices (e.g. brush management), the timing and method of application needs to favor the native species over the exotic species. Adjustments to account for variations in annual growing conditions and implementing an ongoing monitoring protocol to track changes and adjust management inputs to ensure desired outcome will be necessary.

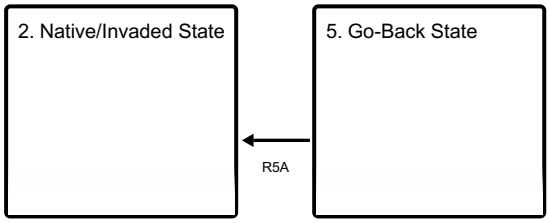
The plant community phase composition table(s) has been developed from the best available knowledge including research, historical records, clipping studies, and inventory records. As more data are collected, plant community species composition and production information may be revised.

State and transition model

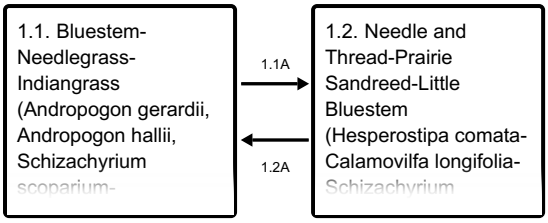
Ecosystem states



States 2 and 5 (additional transitions)



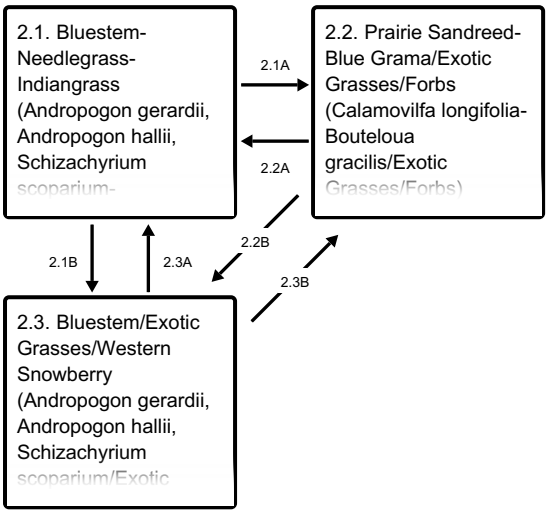
State 1 submodel, plant communities



1.1A - Periods of below average precipitation and increased disturbance

1.2A - Return to average precipitation and disturbance regime

State 2 submodel, plant communities



2.1A - Heavy season-long grazing

2.1B - No use and no fire

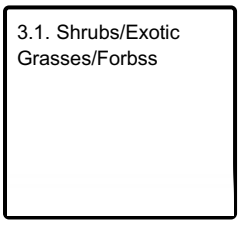
2.2A - Prescribed grazing, prescribed burning

2.2B - No use and no fire

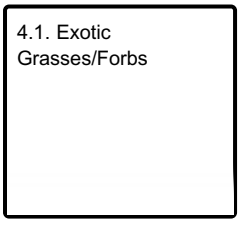
2.3A - Prescribed grazing and prescribed burning

2.3B - Heavy season-long grazing

State 3 submodel, plant communities



State 4 submodel, plant communities



State 5 submodel, plant communities

5.1. Annual/Pioneer Perennial/Exotics

State 1
Reference State

This state represented the natural range of variability that dominated the dynamics of this ecological site prior to European influence. The primary disturbance mechanisms for this site in the reference condition included frequent fire and grazing by large herding ungulates. Timing of fires and grazing coupled with weather events dictated the dynamics that occurred within the natural range of variability. These factors likely caused the community to shift both spatially and temporally between two community phases. This was a diverse, stable, and productive state with the high water table supplying much of the moisture for plant growth. It was dominated by warm-season grasses (i.e. bluestem and Indiangrass) with lesser amounts of cool-season grasses (i.e. needlegrasses). During periods of extended drought, the community shifted to one of needle and thread, prairie sandreed, and little bluestem

Characteristics and indicators. (i.e. characteristics and indicators that can be used to distinguish this state from others). Because of changes in disturbances and other environmental factors (particularly the widespread occurrence of exotic species), the Reference State is considered to no longer exist

Resilience management. (i.e. management strategies that will sustain a state and prevent a transition). If intact, the reference state should probably be managed with current disturbance regimes which has permitted the site to remain in reference condition as well as maintaining the quality and integrity of associated ecological sites. Maintenance of the reference state is contingent upon a monitoring protocol to guide management

Dominant plant species

- prairie willow (*Salix humilis*), shrub
- prairie rose (*Rosa arkansana*), shrub
- leadplant (*Amorpha canescens*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- prairie sagewort (*Artemisia frigida*), shrub
- white meadowsweet (*Spiraea alba*), shrub
- big bluestem (*Andropogon gerardii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- porcupinegrass (*Hesperostipa spartea*), grass
- white sagebrush (*Artemisia ludoviciana*), other herbaceous
- purple prairie clover (*Dalea purpurea*), other herbaceous
- stiff goldenrod (*Oligoneuron rigidum*), other herbaceous
- prairie spiderwort (*Tradescantia occidentalis*), other herbaceous
- Maximilian sunflower (*Helianthus maximiliani*), other herbaceous
- tall blazing star (*Liatris aspera*), other herbaceous

Community 1.1
Bluestem-Needlegrass-Indiangrass (Andropogon gerardii, Andropogon hallii, Schizachyrium scoparium-Hesperostipa spp.-Sorghastrum nutans)

This community phase was the most dominant both temporally and spatially. It was dominated by tall and mid warm-season grasses such as big bluestem, prairie sandreed, and Indiangrass, in association with mid cool-season grasses such as porcupinegrass. Other grass and grass-like species included switchgrass, little bluestem, sideoats grama, needle and thread, blue grama, and sedge. A wide variety of native perennial forbs were present including white sagebrush, purple prairie clover, stiff goldenrod, prairie spiderwort, Maximillian sunflower, and blazing star. Common shrubs included prairie willow, prairie rose, leadplant, western snowberry, prairie sagewort, and white

meadowsweet. Annual production will vary from about 2400-4000 pounds per acre with grasses and grass-likes, forbs, and shrubs contributing about 80%, 10%, and 10% respectively. Because both warm-season grasses and cool-season grasses and sedges are well represented in the community, production would have been distributed throughout the growing season. This community represents the plant community phase upon which interpretations are primarily based and is described in the “Plant Community Composition and Group Annual Production” portion of this ecological site description.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	2365	3049	3654
Shrub/Vine	163	269	415
Forb	163	269	415
Total	**2691**	**3587**	**4484**

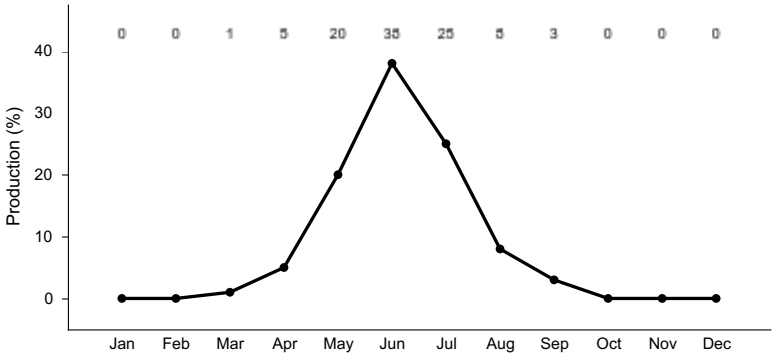


Figure 8. Plant community growth curve (percent production by month). ND5604, Red River Valley of the North, warm-season dominant, cool-season sub-dominant.. Warm-season dominant, cool-season sub-dominant..

Community 1.2
Needle and Thread-Prairie Sandreed-Little Bluestem (Hesperostipa comata-Calamovilfa longifolia-Schizachyrium scoparium)

This community would have been characterized by more drought and grazing tolerant species compared to that that of Community Phase 1.1. Prominent grasses would have included needle and thread, prairie sandreed, little bluestem, sideoats grama, and blue grama. White heath aster, field sagewort, Cuman ragweed, rigid sunflower, and prairie sagewort were among the prominent forbs and shrubs. Annual production would have declined in comparison to that of Community Phase 1.1.

Pathway 1.1A
Community 1.1 to 1.2

Community Pathway 1.1 to 1.2 occurred during periods of below average precipitation and increased disturbance resulting in a decline in the more grazing sensitive species such as big bluestem, Indiangrass, and porcupinegrass with a corresponding increase in the more drought and grazing resistant species such as needle and thread, prairie sandreed, and little bluestem.

Pathway 1.2A
Community 1.2 to 1.1

Community Pathway 1.2 to 1.1 would have occurred with the return to average precipitation and disturbance regime resulting in an increase in the more grazing sensitive species such as big bluestem, Indiangrass, and porcupinegrass with a corresponding decline in the more drought and grazing resistant species such as needle and thread, prairie sandreed, and little bluestem.

State 2
Native/Invaded State

This state is similar to State 1: Reference State but has now been colonized by the exotic cool-season grasses, commonly Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass which are now present in small amounts. Although the state is still dominated by native grasses, an increase in these exotic cool-season grasses can be expected. These exotic cool-season grasses can be quite invasive on the site and are particularly well adapted to heavy grazing. They also often form monotypic stands. As these exotic cool-season grasses increase, both forage quantity and quality become increasingly restricted to late spring and early summer due to the monotypic nature of the stand even though annual production may increase. Native forbs generally decrease in production, abundance, diversity, and richness compared to that of State 1: Reference State. These exotic cool-season grasses have been particularly and consistently invasive under extended periods of no use and no fire. To slow or limit the invasion of these exotic grasses it is imperative that managerial options (e.g. prescribed grazing, prescribed burning) be carefully constructed and evaluated with respect to that objective. If management does not include measures to control or reduce these exotic cool-season grasses the transition to State 4: Invaded State should be expected. Annual production of this state can be quite variable, in large part due to the amount of exotic cool-season grasses. Annual production may, however, range from 2400-4000 pounds per acre.

Characteristics and indicators. The presence of trace amounts of exotic cool-season grasses indicates a transition from State 1 to State 2. The presence of exotic biennial or perennial leguminous forbs (i.e. sweet clover, black medic) may not, on their own, indicate a transition from State 1 to State 2 but may facilitate that transition.

Resilience management. To slow or limit the invasion of these exotic grasses, it is imperative that managerial options (e.g. prescribed grazing, prescribed burning) be carefully constructed and evaluated with respect to that objective. Grazing management should be applied that enhances the competitive advantage of native grass and forb species. This may include: (1) grazing when exotic cool-season grasses are actively growing and native cool-season grasses are dormant; (2) applying proper deferment periods allowing native grasses to recover and maintain or improve vigor; (3) adjusting overall grazing intensity to reduce excessive plant litter (above that needed for rangeland health indicator #14 – see Rangeland Health Reference Worksheet); (4) incorporating early heavy spring utilization which focuses grazing pressure on exotic cool-season grasses and reduces plant litter provided that livestock are moved when grazing selection shifts from exotic cool-season grasses to native grasses. Prescribed burning should be applied in a manner that maintains or enhances the competitive advantage of native grass and forb species. Prescribed burns should be applied as needed to adequately reduce/remove excessive plant litter and maintain the competitive advantage for native species. Timing of prescribed burns (spring vs. summer vs. fall) should be adjusted to account for differences in annual growing conditions and applied during windows of opportunity to best shift the competitive advantage to the native species.

Dominant plant species

- western snowberry (*Symphoricarpos occidentalis*), shrub
- prairie sagewort (*Artemisia frigida*), shrub
- big bluestem (*Andropogon gerardii*), grass
- sand bluestem (*Andropogon hallii*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- porcupinegrass (*Hesperostipa spartea*), grass
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous
- rush (*Juncus*), other herbaceous
- goldenrod (*Solidago*), other herbaceous

Community 2.1
Bluestem-Needlegrass-Indiangrass (Andropogon gerardii, Andropogon hallii, Schizachyrium scoparium-Hesperostipa spp.-Sorghastrum nutans)

This community phase is similar to Community Phase 1.1 but has been colonized by exotic cool-season grasses which are now minor components of the community. The warm- and cool-season co-dominated community is maintained with grazing systems that allow for adequate recovery periods following grazing events and, potentially, the combination of grazing and prescribed burning which closely mimics the natural disturbance regime. Annual

production is similar to that of Community Phase 1.1 (2400-4000 pounds per acre) with graminoids, forbs and shrubs contributing roughly 80%, 10%, and 10% of the production respectively.

Table 6. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	2365	3049	3654
Shrub/Vine	163	269	415
Forb	163	269	415
Total	**2691**	**3587**	**4484**

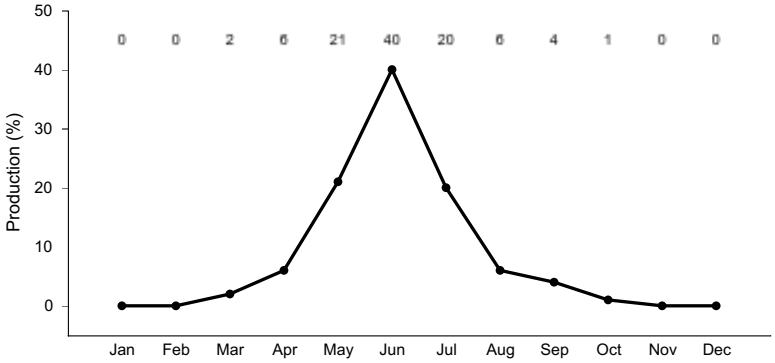


Figure 10. Plant community growth curve (percent production by month). ND5603, Red River Valley of the North, warm-season/cool-season co-dominant.. Cool-season, warm-season co-dominant..

Community 2.2
Prairie Sandreed-Blue Grama/Exotic Grasses/Forbs (Calamovilfa longifolia-Bouteloua gracilis/Exotic Grasses/Forbs)

Grazing pressure has reduced the mid/tall less grazing tolerant species, while the shorter more grazing tolerant species have increased compared to Community Phase 2.1. Common grasses often include prairie sandreed, blue grama, needle and thread, Kentucky bluegrass, and/or other exotic cool-season grasses. The common forbs include Cuman ragweed, scouring rush, and goldenrod. Western snowberry and prairie sagewort are common shrubs. Compared to Community Phase 2.1, litter has decreased and peak production has shifted to slightly earlier in the growing season due to a decline in the later maturing warm-season grasses and an corresponding increase in native and exotic cool-season grasses. Annual production is similar to that of Community Phase 2.1 (2400-4000 pounds per acre) with contributions from Kentucky bluegrass or other exotic cool-season grasses approaching 30% of the production. This community phase is often dispersed throughout the pasture, in an overgrazed/undergrazed pattern, typically referred to as patch grazing. Some areas (overgrazed) will exhibit the impacts of heavy use, while other areas (undergrazed) will have a build-up of litter and a high amount of plant decadence. This is a typical pattern found in properly stocked pastures grazed season-long. In the undergrazed patches, litter buildup reduces plant vigor and density and native seedling recruitment declines. Due to a lack of tiller stimulation and sunlight, native bunchgrasses typically develop dead centers and native rhizomatous grasses are limited to small colonies. In the overgrazed patches, plant vigor is reduced; the competitive advantage goes towards the grazing tolerant species such as Kentucky bluegrass. This Community Phase is approaching the threshold leading to a transition to State 4: Invaded State. As a result, it is an “at risk” community. If management does not include measures to control or reduce these exotic cool-season grasses, the transition to State 4: Invaded State should be expected.

Community 2.3
Bluestem/Exotic Grasses/Western Snowberry (Andropogon gerardii, Andropogon hallii, Schizachyrium scoparium/Exotic Grasses/Symphoricarpos occidentalis)

The removal of disturbances has allowed the exotic cool-season grasses (commonly Kentucky bluegrass) to increase to 20 to 30 percent of the annual production. Tall and mid statured warm and cool season native grasses such as big bluestem, Indiangrass, switchgrass, little bluestem, sideoats grama, porcupinegrass, and needle and thread constitute at least 40 percent of the annual production. Native forbs such as Maximilian sunflower,

goldenrods, white heath aster, common yarrow, Cuman ragweed, and white sagebrush are present along with exotic forbs such as sweet clover and black medic. Western snowberry and prairie rose are common shrubs. Smooth brome may encroach onto the site, particularly when adjacent to right-of-ways. Annual production is similar to the reference plant community (2400-4000 pounds per acre) but peak production has shifted to early spring to mid-summer due to the invasion of exotic cool-season grasses. Litter cover (extent) is similar to the reference plant community; however, the depth has increased to greater than 5 inches and is not in contact with the soil surface. This Community Phase is approaching the threshold leading to a transition to State 4: Invaded State. As a result, it is an “at risk” community. If management does not include measures to control or reduce these exotic cool-season grasses, the transition to State 4: Invaded State should be expected.

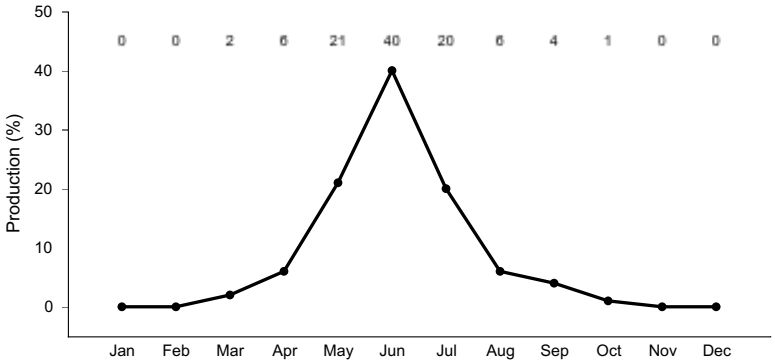


Figure 11. Plant community growth curve (percent production by month). ND5603, Red River Valley of the North, warm-season/cool-season co-dominant.. Cool-season, warm-season co-dominant..

Pathway 2.1A
Community 2.1 to 2.2

Community Phase Pathway 2.1 to 2.2 occurs during periods of heavy season-long grazing or seasonal grazing without adequate recovery periods (grazing at the same season of year for extended periods during the active growing season of the dominant native grasses). This results in a marked decline in the big bluestem, little bluestem, porcupinegrass, and Indiangrass, with a corresponding increase in the exotic cool-season grasses, blue grama, prairie sandreed, and forbs.

Pathway 2.1B
Community 2.1 to 2.3

Community Phase Pathway 2.1 to 2.3 occurs during periods of no use and no fire. Plant litter increases and the exotic cool-season grasses (often Kentucky bluegrass) and western snowberry markedly increase.

Pathway 2.2A
Community 2.2 to 2.1

Community Phase Pathway 2.2 to 2.1 is initiated by implementation of prescribed grazing and prescribed burning to suppress the exotic cool-season grasses and enable the native grasses, particularly the warm-season species to increase. Prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources. If properly implemented, this will shift the competitive advantage from the exotic cool-season species to the native cool-season and warm-season grass species.

Conservation practices

Prescribed Burning
Prescribed Grazing

Pathway 2.2B
Community 2.2 to 2.3

Community Phase Pathway 2.2 to 2.3 occurs during periods of no use and no fire. This leads to an increase in the

exotic cool-season grasses (often Kentucky bluegrass), western snowberry, and litter, with a corresponding decrease in forbs and native grasses, particularly the warm-season species

Pathway 2.3A
Community 2.3 to 2.1

Community Phase Pathway 2.3 to 2.1 is initiated by implementation of prescribed grazing and prescribed burning. The prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources. The application of several prescribed burns may be needed at relatively short intervals in the early pathway, in part because western snowberry and some other shrubs sprout profusely following one burn. Early season prescribed burns have been successful; however, fall burning may also be an effective technique.

Conservation practices

Prescribed Burning
Prescribed Grazing

Pathway 2.3B
Community 2.3 to 2.2

Community Phase Pathway 2.3 to 2.2 occurs with heavy season-long grazing. This results in a decrease in the exotic cool-season grasses (often Kentucky bluegrass), western snowberry, and litter, with a corresponding increase in forbs and native grasses, particularly the warm-season grasses.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 3
Wooded State

This state historically existed as small patches of shrubs and perhaps trees scattered across the site, particularly when near wooded areas where they could have encroached onto the site vegetatively (e.g. rhizomes, root sprouts) or provided a seed source for colonization of the site. Common woody species often include western snowberry, prairie rose, Wood’s rose, white meadowsweet, and willow. Trees such as quaking aspen and green ash may also be present. A marked increase in non-use management and active fire suppression since European influence has enabled this state to expand and become more widespread.

Characteristics and indicators. As trees and shrubs increase in size and density, canopy cover increases which alters micro-climate and reduces fine fuel amounts resulting in reduced fire intensity and frequency. Diversity and production of herbaceous understory is reduced as canopy cover increases.

Dominant plant species

- quaking aspen (*Populus tremuloides*), tree
- green ash (*Fraxinus pennsylvanica*), tree
- eastern cottonwood (*Populus deltoides*), tree
- western snowberry (*Symphoricarpos occidentalis*), shrub
- prairie rose (*Rosa arkansana*), shrub
- Woods' rose (*Rosa woodsii*), shrub
- white meadowsweet (*Spiraea alba*), shrub
- willow (*Salix*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- quackgrass (*Elymus repens*), grass

- American licorice (*Glycyrrhiza lepidota*), other herbaceous
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- common yarrow (*Achillea millefolium*), other herbaceous

Community 3.1
Shrubs/Exotic Grasses/Forbss

Shrubs such as western snowberry, prairie rose, Wood's rose, white meadowsweet, and willow increase to become major components in this community phase. The herbaceous understory is dominated by the shade-tolerant, cool-season sodgrasses such as Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass. Common forbs include goldenrod, American licorice, Cuman ragweed, white heath aster, and common yarrow. Quaking aspen, green ash, and perhaps other trees may also be present. Remnants of native warm- and cool-season grasses are still present, but greatly reduced in extent, vigor and production. This community phase is somewhat resistant to change. Once established, time and external resources will be needed to see any immediate recovery. The combination of both prescribed grazing and prescribed fire is the most effective in moving this plant community towards State 2: Native/Invaded State.

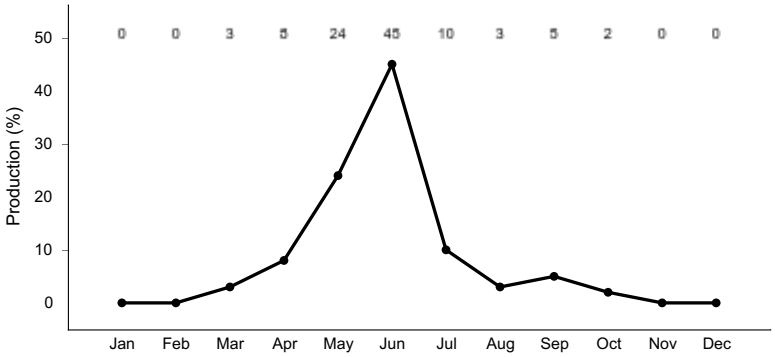


Figure 12. Plant community growth curve (percent production by month). ND5601, Red River Valley of the North, cool-season dominant.. Cool-season dominant..

State 4
Invaded State

This state is the result of invasion and dominance by the exotic cool-season grasses, commonly Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass. The exotic leafy spurge and Canada thistle are also known to invade the site. The exotic cool-season grasses can be quite invasive on the site and are particularly well adapted to heavy grazing. They also often form monotypic stands. As these exotic cool-season grasses increase, both forage quantity and quality become increasingly restricted to late spring and early summer due to the monotypic nature of the stand even though annual production may increase. Native forbs generally decrease in production, abundance, diversity, and richness compared to that of State 1: Reference State. Common forbs often include white heath aster, goldenrod, common yarrow, and white sagebrush. Shrubs such as western snowberry and rose may, however, show marked increases. Once the state is well established, prescribed burning and grazing techniques have been largely ineffective in suppressing or eliminating these three species even though some short-term reductions may appear successful. Annual production of this state may vary widely, in part due to variations in the extent of invasion by exotic cool-season grasses. However, annual production may be in the range of 3300-5300 pounds per acre.

Characteristics and indicators. This site is characterized by exotic cool-season grasses constituting greater than 30 percent of the annual production and native grasses constituting less than 40 percent of the annual production.

Resilience management. Light or moderately stocked continuous, season-long grazing or a prescribed grazing system which incorporates adequate deferment periods between grazing events and proper stocking rate levels will maintain this State. Application of herbaceous weed treatment, occasional prescribed burning, and/or brush management may be needed to manage noxious weeds and increasing shrub (e.g. western snowberry) populations

Dominant plant species

- western snowberry (*Symphoricarpos occidentalis*), shrub
- prairie rose (*Rosa arkansana*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- quackgrass (*Elymus repens*), grass
- leafy spurge (*Euphorbia esula*), other herbaceous
- sweetclover (*Melilotus officinalis*), other herbaceous
- black medick (*Medicago lupulina*), other herbaceous
- Canada thistle (*Cirsium arvense*), other herbaceous
- goldenrod (*Solidago*), other herbaceous

Community 4.1
Exotic Grasses/Forbs

This community phase is dominated by exotic cool-season sodgrasses such as Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass. Excessive accumulation of mulch may also be present, particularly when dominated by Kentucky bluegrass. Common forbs often include goldenrod, common yarrow, asters, and Cuman ragweed. Exotic forbs such as leafy spurge and Canada thistle are also known to invade the site. Rose and western snowberry are common shrubs. Annual production of this state may vary widely, in part due to variations in the extent of invasion by exotic cool-season grasses. However, annual production may be in the range of 3300-5300 pounds per acre. The longer this community phase exists the more resilient it becomes. Natural or management disturbances that reduce the cover of exotic cool-season grasses are typically short lived.

State 5
Go-Back State

This state is highly variable depending on the level and duration of disturbance related to the T6A transitional pathway. In this MLRA, the most probable origin of this state is plant succession following cropland abandonment. This plant community will initially include a variety of annual forbs and grasses, some of which may be noxious weeds and need control. Over time, the exotic cool-season grasses Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass will likely predominate.

Dominant plant species

- smooth brome (*Bromus inermis*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- cheatgrass (*Bromus tectorum*), grass
- leafy spurge (*Euphorbia esula*), other herbaceous
- Canada thistle (*Cirsium arvense*), other herbaceous
- field sowthistle (*Sonchus arvensis*), other herbaceous
- sweetclover (*Melilotus officinalis*), other herbaceous

Community 5.1
Annual/Pioneer Perennial/Exotics

This community phase is highly variable depending on the level and duration of disturbance related to the T6A transitional pathway. In this MLRA, the most probable origin of this phase is secondary succession following cropland abandonment. This plant community will initially include a variety of annual forbs and grasses, including noxious weeds (e.g. Canada thistle, leafy spurge) which may need control. Over time, the exotic cool-season grasses Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass will likely predominate.

State 6
Cropland State

Cropland State results from planting and production of annual crops. This plant community is most commonly associated with cropped fields. Soil conditions can be quite variable on the site, in part due to variations in the management/cropping history (e.g. development of tillage induced compaction, erosion, fertility, herbicide/pesticide carryover). Thus, soil conditions should be assessed when considering restoration techniques..

Dominant plant species

- corn (*Zea*), other herbaceous
- soybean (*Glycine*), other herbaceous

Transition T1A
State 1 to 2

This is the transition from the State 1: Reference State to the State 2: Native/Invaded State due to the introduction and establishment of exotic cool-season grasses, typically Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass. This transition was probably inevitable and corresponded to a decline in native warm-season and cool-season grasses. This transition may have been exacerbated by chronic season-long or heavy late season grazing. Complete rest from grazing and suppression of fire could also have hastened the transition. The threshold between states was crossed when Kentucky bluegrass, smooth bromegrass, quackgrass, crested wheatgrass or other exotic species became established on the site.

Constraints to recovery. Current knowledge and technology will not facilitate a successful restoration to Reference State.

Transition T3A
State 1 to 3

This is the transition from State 3: Wooded State to State 4: Invaded State resulting from brush control (e.g. mechanical and/or chemical, repeated prescribed burns).

Constraints to recovery. Labor and financial cost of removal/control of woody species either through repeated prescribed burns, mechanical and/or chemical treatment.

Context dependence. Societal norms have accepted woody invasion as positive for wildlife habitat, carbon sequestration, aesthetics, etc. Livestock managers may not understand the loss of production due to woody invasion and loss of native grass species. Wildlife managers may need to manage woody habitat for exotic wildlife species such as ring-necked pheasants instead of sharp-tailed grouse or other grassland nesting birds which are intolerant to woody species invasion.

Transition T2A
State 2 to 3

This transition from the State 2: Native/Invaded to State 3: Wooded State generally occurs during extended periods of no use or very light grazing and no fire. It frequently occurs when the site is in close proximity to wooded areas where the woodland vegetation may encroach vegetatively upon the site and/or serve as a seed source for these species to colonize the site. It has also become more frequent following European settlement when the historic fire regime was markedly reduced.

Transition T2B
State 2 to 4

This transition from the State 2: Native/Invaded State to State 4: Invaded State generally occurs with heavy season-long grazing. Exotic cool-season grasses such as Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass become the dominant graminoids. Studies indicate that a threshold may exist in this transition when Kentucky bluegrass exceeds 30% of the plant community and native grasses represent less than 40% of the plant community composition. Similar thresholds may exist for smooth brome and quackgrass. This transition may occur under a wide range of managerial conditions ranging from no use and no fire to heavy season-long grazing (primarily Kentucky bluegrass).

Restoration pathway R3A
State 3 to 2

This restoration from State 3: Wooded State to State 2: Native/Invaded State can be accomplished with brush control, perhaps followed by a range planting. Initial use of herbicides and/or mechanical brush control to reduce the shrubs will permit adequate fine fuel loads to enable the application of prescribed burning to further control sprouting shrubs species. However, depending upon level of remnant native grasses and forbs, a range planting may also be necessary to complete the restoration. A combination of mechanical brush management, chemical treatment, and prescribed burning is necessary to remove the woody vegetation and, if necessary, to prepare the seedbed for a successful range planting. Once this is accomplished, it may be possible using selected plant materials and agronomic practices to approach something very near the functioning of State 2: Native/Invaded State. Application of chemical herbicides and the use of mechanical seeding methods using adapted varieties of the dominant native grasses are possible and can be successful. The application of several prescribed burns may be needed at relatively short intervals in the early phases of this restoration process, in part because many of the shrubs (e.g. western snowberry) sprout profusely following one burn. After establishment of the native plant species, management objectives must include the maintenance of those species, the associated reference state functions, and continued treatment of exotic grasses. Due to the resprouting nature of woody species within MLRA 56, repeated treatments will be necessary for a transition from this state. Following the removal of woody species, other restoration practices such as range planting, prescribed burning, and prescribed grazing may be necessary to complete the restoration. The prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources. If properly implemented, this will help suppress any exotic cool-season grasses on the site.

Context dependence. Prescribed burning should be applied in a manner that enhances the competitive advantage of native grass and forb species over the exotic species. Prescribed burns should be applied at a frequency which mimics the natural disturbance regime or more frequently as is ecologically (e.g. available fuel load) and economically feasible. Burn prescriptions may need adjustment to: (1) account for change in fuel type (herbaceous vs. shrub vs. tree), fine fuel amount and orientation; (2) fire intensity and duration by adjusting ignition pattern (e.g. backing fires vs head fires); (3) account for plant phenological stages to maximize stress on woody and exotic species while favoring native species (both cool- and warm-season grasses). The method of brush management will be site specific but generally the goal would be to apply the pesticide, mechanical control, or biological control - either singularly or in combination - in a manner that shifts the competitive advantage from the targeted species to the native grasses and forbs. The control method(s) should be as specific to the targeted species as possible to minimize impacts to non-target species. A successful range planting will include proper seedbed preparation, weed control (both prior to and after the planting), selection of adapted native species representing functional/structural groups inherent to the State 1, and proper seeding technique. Management (e.g. prescribed grazing, prescribed burning) during and after establishment must be applied in a manner that maintains the competitive advantage for the seeded native species. Adding non-native species can impact the above and below ground biota. Some evidence suggests the addition of exotic legumes to the seeding mixture may favor exotic cool-season grass expansion/invasion.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing
Herbaceous Weed Control

Transition T3A
State 3 to 4

This is the transition from State 3: Wooded State to State 4: Invaded State resulting from brush control (e.g. mechanical and/or chemical, repeated prescribed burns).

Constraints to recovery. Labor and financial cost of removal/control of woody species either through repeated prescribed burns, mechanical and/or chemical treatment.

Context dependence. Societal norms have accepted woody invasion as positive for wildlife habitat, carbon sequestration, aesthetics, etc. Livestock managers may not understand the loss of production due to woody

invasion and loss of native grass species. Wildlife managers may need to manage woody habitat for exotic wildlife species such as ring-necked pheasants instead of sharp-tailed grouse or other grassland nesting birds which are intolerant to woody species invasion.

Restoration pathway R4A
State 4 to 2

This restoration pathway from State 4: Invaded State to State 2: Native/Invaded State may be accomplished with the implementation of long-term prescribed grazing and prescribed burning, assuming there is an adequate component of native grasses to respond to the treatments. Both prescribed grazing and prescribed burning are likely necessary to successfully initiate this restoration pathway, the success of which depends upon the presence of a remnant population of native grasses in Community Phase 4.1. That remnant population, however, may not be readily apparent without close inspection. The application of several prescribed burns may be needed at relatively short intervals in the early phases of this restoration process, in part because many of the shrubs (e.g. western snowberry) sprout profusely following one burn. Early season prescribed burns have been successful; however, fall burning may also be an effective technique. The prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources. If properly implemented, this will shift the competitive advantage from the exotic cool-season grasses to the native cool-season grasses.

Context dependence. Grazing management should be applied in a manner that enhances/maximizes the competitive advantage of native grass and forb species over the exotic species. This may include the use of prescribed grazing to reduce excessive plant litter accumulations above that needed for rangeland health indicator #14 (see Rangeland Health Reference Worksheet). Increasing livestock densities may facilitate the reduction in plant litter provided length and timing of grazing periods are adjusted to favor native species. Grazing prescriptions designed to address exotic grass invasion and favor native species may involve earlier, short, intense grazing periods with proper deferment to improve native species health and vigor. Fall (e.g. September, October) prescribed burning followed by an intensive, early spring graze period with adequate deferment for native grass recovery may shift the competitive advantage to the native species, facilitating the restoration to State 2: Native/Invaded. Prescribed burning should be applied in a manner that enhances the competitive advantage of native grass and forb species over the exotic species. Prescribed burns should be applied at a frequency which mimics the natural disturbance regime, or more frequently as is ecologically (e.g. available fuel load) and economically feasible. Burn prescriptions may need adjustment to: (1) account for change in fine fuel orientation (e.g. “flopped” Kentucky bluegrass); (2) fire intensity and duration by adjusting ignition pattern (e.g. backing fires vs head fires); (3) account for plant phenological stages to maximize stress on exotic species while favoring native species (both cool- and warm-season grasses). The longer this community phase exists, the more resilient it becomes. Natural or management disturbances that reduce the cover of Kentucky bluegrass or smooth brome are typically short-lived.

Transition T4A
State 4 to 3

The transition from State 4: Invaded Site to State 3: Wooded State generally occurs during extended periods of no use or very light grazing and no fire. It frequently occurs when the site is in close proximity to wooded areas where the woodland vegetation may encroach vegetatively upon the site and/or serve as a seed source for these species to colonize the site. It has also become more frequent following European settlement when the historic fire regime was markedly reduced.

Restoration pathway R5A
State 5 to 2

This Restoration Pathway from State 5: Go-Back State to the State 2: Native/Invaded State can be accomplished with a successful range planting. Following seeding, prescribed grazing, prescribed burning, haying, or use of herbicides will generally be necessary to achieve the desired result and control any noxious weeds. It may be possible using selected plant materials and agronomic practices to approach something very near the functioning of State 2: Native/Invaded State. Application of chemical herbicides and the use of mechanical seeding methods using adapted varieties of the dominant native grasses are possible and can be successful. After establishment of the native plant species, prescribed grazing should include adequate recovery periods following each grazing event and stocking levels which match the available resources; management objectives must include the maintenance of those species, the associated reference state functions, and continued treatment of exotic grasses.

Restoration pathway R5B
State 5 to 4

A failed range planting and/or secondary succession will lead to State 4: Invaded State

Context dependence. Failed range plantings can result from many causes, both singularly and in combination, including: drought, poor seedbed preparation, improper seeding methods, seeded species not adapted to the site, insufficient weed control, herbicide carryover, poor seed quality (purity & germination), improper management.

Transition T6A
State 6 to 5

This transition from any plant community to State 5: Go-Back State. It is most commonly associated with the cessation of cropping without the benefit of range planting, resulting in a “go-back” situation. Soil conditions can be quite variable on the site, in part due to variations in the management/cropping history (e.g. development of a tillage induced compaction layer, erosion, fertility, herbicide/pesticide carryover). Thus, soil conditions should be assessed when considering restoration techniques.

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Tall Warm-Season Grasses**			538–897	
	prairie sandreed	CALO	*Calamovilfa longifolia*	179–538	–
	big bluestem	ANGE	*Andropogon gerardii*	179–538	–
	switchgrass	PAVI2	*Panicum virgatum*	72–359	–
	Indiangrass	SONU2	*Sorghastrum nutans*	72–359	–
	sand bluestem	ANHA	*Andropogon hallii*	0–179	–
	prairie cordgrass	SPPE	*Spartina pectinata*	0–72	–
2	**Cool-Season Bunchgrasses**			179–538	
	porcupinegrass	HESP11	*Hesperostipa spartea*	179–538	–
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	36–179	–
	Canada wildrye	ELCA4	*Elymus canadensis*	0–108	–
	slender wheatgrass	ELTR7	*Elymus trachycaulus*	0–108	–
3	**Mid Warm-Season Grasses**			179–538	
	little bluestem	SCSC	*Schizachyrium scoparium*	179–538	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	72–359	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–179	–
4	**Mid Cool-Season Grasses**			72–179	
	western wheatgrass	PASM	*Pascopyrum smithii*	0–179	–
5	**Short Warm-Season Grasses**			36–179	
	blue grama	BOGR2	*Bouteloua gracilis*	36–179	–
6	**Other Native Grasses**			36–179	
	Graminoid (grass or grass-like)	2GRAM	*Graminoid (grass or grass-like)*	36–179	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	36–108	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var.*	0–72	–

			scribnerianum		
	fall rosette grass	DIWI5	*Dichanthelium wilcoxianum*	0–72	–
7	**Grass-likes**			72–359	
	sun sedge	CAINH2	*Carex inops ssp. heliophila*	36–287	–
	Pennsylvania sedge	CAPE6	*Carex pensylvanica*	36–287	–
	Grass-like (not a true grass)	2GL	*Grass-like (not a true grass)*	0–108	–
Forb					
8	**Forbs**			179–359	
	white sagebrush	ARLU	*Artemisia ludoviciana*	36–108	–
	Forb, native	2FN	*Forb, native*	36–108	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	36–72	–
	purple prairie clover	DAPU5	*Dalea purpurea*	36–72	–
	smooth horsetail	EQLA	*Equisetum laevigatum*	36–72	–
	flat-top goldentop	EUGR5	*Euthamia graminifolia*	36–72	–
	stiff goldenrod	OLRI	*Oligoneuron rigidum*	36–72	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	36–72	–
	white heath aster	SYER	*Symphyotrichum ericoides*	36–72	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	36–72	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	0–72	–
	field sagewort	ARCA12	*Artemisia campestris*	0–36	–
	prairie milkweed	ASSU3	*Asclepias sullivantii*	0–36	–
	Geyer's sandmat	CHGE2	*Chamaesyce geyeri*	0–36	–
	Canadian horseweed	COCAC3	*Conyza canadensis var. canadensis*	0–36	–
	silky prairie clover	DAVI	*Dalea villosa*	0–36	–
	blazing star	LIATR	*Liatris*	0–36	–
	narrowleaf stoneseed	LIIN2	*Lithospermum incisum*	0–36	–
	lobelia	LOBEL	*Lobelia*	0–36	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–36	–
Shrub/Vine					
9	**Shrubs**			179–359	
	prairie willow	SAHU2	*Salix humilis*	0–143	–
	leadplant	AMCA6	*Amorpha canescens*	36–108	–
	prairie rose	ROAR3	*Rosa arkansana*	36–108	–
	white meadowsweet	SPAL2	*Spiraea alba*	36–108	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–108	–
	western snowberry	SYOC	*Symphoricarpos occidentalis*	36–72	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–36	–

Table 8. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Tall Warm-Season Grasses**			538–897	
	big bluestem	ANGE	*Andropogon gerardii*	179–538	–

	prairie sandreed	CALO	*Calamovilfa longifolia*	179–538	–
	switchgrass	PAVI2	*Panicum virgatum*	72–359	–
	Indiangrass	SONU2	*Sorghastrum nutans*	72–359	–
	sand bluestem	ANHA	*Andropogon hallii*	0–179	–
	prairie cordgrass	SPPE	*Spartina pectinata*	0–72	–
2	**Cool-Season Bunchgrasses**			179–538	
	porcupinegrass	HESP11	*Hesperostipa spartea*	179–538	–
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	36–179	–
	Canada wildrye	ELCA4	*Elymus canadensis*	0–108	–
	slender wheatgrass	ELTR7	*Elymus trachycaulus*	0–108	–
3	**Mid Warm-Season Grasses**			179–538	
	little bluestem	SCSC	*Schizachyrium scoparium*	179–538	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	72–359	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–179	–
4	**Mid Cool-Season Grasses**			72–179	
	western wheatgrass	PASM	*Pascopyrum smithii*	0–179	–
5	**Short Warm-Season Grasses**			36–179	
	blue grama	BOGR2	*Bouteloua gracilis*	36–179	–
6	**Other Native Grasses**			36–179	
	Graminoid (grass or grass-like)	2GRAM	*Graminoid (grass or grass-like)*	36–179	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	36–108	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	0–72	–
	fall rosette grass	DIWI5	*Dichanthelium wilcoxianum*	0–72	–
7	**Grass-likes**			72–359	
	sun sedge	CAINH2	*Carex inops ssp. heliophila*	36–287	–
	Pennsylvania sedge	CAPE6	*Carex pensylvanica*	36–287	–
	Grass-like (not a true grass)	2GL	*Grass-like (not a true grass)*	0–108	–
8	**Exotic Cool-Season Grasses**			36–179	
	Kentucky bluegrass	POPR	*Poa pratensis*	0–179	–
	quackgrass	ELRE4	*Elymus repens*	0–179	–
Forb					
9	**Forbs**			179–359	
	Forb, native	2FN	*Forb, native*	36–108	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	36–108	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	36–72	–
	purple prairie clover	DAPU5	*Dalea purpurea*	36–72	–
	smooth horsetail	EQLA	*Equisetum laevigatum*	36–72	–
	flat-top goldentop	EUGR5	*Euthamia graminifolia*	36–72	–
	stiff goldenrod	OLRI	*Oligoneuron rigidum*	36–72	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	36–72	–
	white heath aster	SYER	*Symphyotrichum ericoides*	36–72	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	36–72	–

	prairie sagewort	ARFR4	*Artemisia frigida*	0–36	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	0–72	–
	field sagewort	ARCA12	*Artemisia campestris*	0–36	–
	prairie milkweed	ASSU3	*Asclepias sullivantii*	0–36	–
	Geyer's sandmat	CHGE2	*Chamaesyce geyeri*	0–36	–
	Canadian horseweed	COCAC3	*Conyza canadensis var. canadensis*	0–36	–
	silky prairie clover	DAVI	*Dalea villosa*	0–36	–
	blazing star	LIATR	*Liatris*	0–36	–
	narrowleaf stoneseed	LIIN2	*Lithospermum incisum*	0–36	–
	lobelia	LOBEL	*Lobelia*	0–36	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–36	–
10	**Exotic Forbs**			36–179	
	leafy spurge	EUES	*Euphorbia esula*	0–179	–
	sweetclover	MELIL	*Melilotus*	0–179	–
	black medick	MELU	*Medicago lupulina*	0–179	–
Shrub/Vine					
11	**Shrubs**			179–359	
	prairie willow	SAHU2	*Salix humilis*	0–143	–
	leadplant	AMCA6	*Amorpha canescens*	36–108	–
	prairie rose	ROAR3	*Rosa arkansana*	36–108	–
	white meadowsweet	SPAL2	*Spiraea alba*	36–108	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–108	–
	western snowberry	SYOC	*Symphoricarpos occidentalis*	36–72	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–36	–

Inventory data references

This is a provisional ecological site, and as such no field plots were inventoried for this project. MLRA 56 was split into 2 MLRAs 56A and 56B with Agricultural Handbook 296 (2022). All information was taken from original MLRA 56 ecological site descriptions in which MLRA 56B was part of. Future field verification is needed to refine the plant communities and ecological dynamics described in this ecological site description.

Other references

Bluemle. J.P. 2016. North Dakota’s Geologic Legacy. North Dakota State University Press. 382 pages.

Briske, D.D. (editor). 2017. Rangeland Systems – Processes, Management, and Challenges. Springer Series on Environmental Management. 661 pages.

Burgess, R.L. 1965. A study of plant succession in the sandhills of southeastern North Dakota. Proceedings ND Academy of Science 19:62-80

DeKeyser, E.S., G. Clambey, K. Krabbenhoft, and J. Ostendorf. 2009. Are changes in species composition on central North Dakota rangelands due to non-use management? Rangelands 31:16-19

Dix, R.L. and F.E. Smeins. 1967. The prairie, meadow, and marsh vegetation of Nelson County, North Dakota. Canadian Journal of Botany 45:21-57.

Dornbusch, M.J., R.F. Limb, and C.K. Gasch. 2018. Facilitation of an exotic grass through nitrogen enrichment by an exotic legume. Rangeland Ecology & Management 71:691-694.

Dyke, S.R., S.K. Johnson, and P.T. Isakson. 2015. North Dakota State Wildlife Action Plan. North Dakota Game and Fish Department, Bismarck, ND. 468 pages.

Ereth, C., J. Hendrickson, D. Kirby, E. DeKeyser, K. Sedevic, and M. West. Controlling Kentucky bluegrass with herbicide and burning is influenced by invasion level. Invasive Plant Science and Management 10: 80-89.

Ewing, J. 1924. Plant Succession on the Brush Prairie in Northwestern Minnesota. Journal of Ecology 12:228-266.

Grant, T.A. and R.K. Murphy. 2005. Changes on woodland cover on prairie refuges in North Dakota, USA. Natural Areas Journal 25:359-368.

Hansen, K. 1996. The Vegetation of the Sheyenne National Grassland: An Ecological Classification. USFS.

Hanson, J.D. 1976. A phytosociological study of oak savanna in southeastern North Dakota. M.S. thesis. North Dakota State University. 135 pages.

Hendrickson, J.R., S.L. Kronberg, and E.J. Scholljegerdes. 2020. Can targeted grazing reduce abundance of invasive perennial grass (Kentucky Bluegrass) on native mixed-grass prairie? Rangeland Ecology and Management, 73:547-551.

Higgins, K.F. 1984. Lightning fires in grasslands in North Dakota and in pine-savanna lands in nearby South Dakota and Montana. J. Range Manage. 37:100-103.

Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the northern great plains. United States Department of Interior, Fish and Wildlife Service. Resource Publication 161. 39 pages.

High Plains Regional Climate Center, University of Nebraska, 830728 Chase Hall, Lincoln, NE 68583-0728. (http://hprcc.unl.edu)
Johnson, Sandra. 2015. Reptiles and Amphibians of North Dakota. North Dakota Game and Fish Department. 64 pages.

Jordan, N. R., D.L. Larson, and S.C. Huerd. 2008. Soil modification by invasive plants: effects on native and invasive species of mixed-grass prairies. Biological Invasions 10:177-190.

Minnesota Department of Natural Resources. 2005. Field guide to the native plant communities of Minnesota – the prairie parkland and tallgrass aspen parklands provinces. Minnesota DNR.

Nelson, W.T. 1986. Grassland habitat type classification of the Sheyenne National Grasslands of southeastern North Dakota. M.S. thesis. North Dakota State University. 139 pages.

North Dakota Division of Tourism, Accessed on February 25, 2019. Available at https://www.ndtourism.com/sports-recreation

North Dakota Parks and Recreation Department, Accessed on February 25, 2019. Available at https://www.parkrec.nd.gov/

Ralston, R.D., and R.L. Dix. 1966. Green herbage production of native grasslands in the Red River Valley-1965. Proceedings ND Academy of Science 20:57-66.

Reeves, J.L., J.D. Derner, M.A. Sanderson, J.R. Hendrickson, S.L. Kronberg, M.K. Petersen, and L.T. Vermeire. 2014. Seasonal weather influences on yearling beef steer production in C3-dominated Northern Great Plains rangeland. Agriculture, Ecosystems and Environment 183:110-117.

Royer, R. A., 2003. Butterflies of North Dakota: An Atlas and Guide. Minot State University, Minot, ND.

Seabloom, R. 2011. Mammals of North Dakota. North Dakota Institute for Regional Studies, Fargo, ND. 461 pages.

Seiler, G.J. and W.T. Barker. 1985. Vascular flora of Ransom, Richland, and Sargent Counties, North Dakota. The

Prairie Naturalist 17:193-240.

Severson, K. E. and C. Hull Sieg. 2006. The Nature of Eastern North Dakota: Pre-1880 Historical Ecology. North Dakota Institute for Regional Studies.

Spaeth, K.E., Hayek, M.A., Toledo, D., and Hendrickson, J. 2019. Cool Season Grass Impacts on Native Mixedgrass Prairie Species in the Norther Great Plains. America's Grassland Conference: Working Across Boundaries. The Fifth Biennial Conference on the Conservation of America's Grasslands. Bismarck, ND. 20-22 August.

Stroh, R. K. 2002. Native Woodlands Habitat Type Classification for the Sheyenne National Grassland, North Dakota. North Dakota State University.

Swingen, M., R, M. Walker, R. Baker, G. Nordquist, T. Catton, K. Kirschbaum, B. Dirks, and N. Dietz. 2018. Northern Long-eared Bat Roost Tree Characteristics 2015-2017. Natural Research Institute, University of Minnesota Duluth, Technical Report NRRI/TR-2018/41, 88p.

USDA, NRCS. National Range and Pasture Handbook, September 1997

USDA, NRCS. National Soil Information System, Information Technology Center, 2150 Centre Avenue, Building A, Fort Collins, CO 80526. (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/tools/?cid=nrcs142p2_053552)

USDA, NRCS. National Water and Climate Center, 101 SW Main, Suite 1600, Portland, OR 97204-3224. https://www.nrcs.usda.gov/wps/portal/wcc/home/

USDA, NRCS. 2001. The PLANTS Database, Version 3.1 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

USDA, NRCS, Various Published Soil Surveys.

Vinton, M.A. and E.M. Goergen. 2006. Plant-soil feedbacks contribute to the persistence of Bromus intermis in tallgrass prairie. Ecosystems 9: 967-976.

Wanek, W. J., and R. L. Burgess. 1965. Floristic Composition of the Sand Prairies of Southeastern North Dakota. Proceedings North Dakota Academy of Science 19:26-40.

Contributors

Jeff Printz
Mark Hayek
Steve Sieler
Alan Gulsvig
Chuck Lura
David Dewald

Approval

Suzanne Mayne-Kinney, 9/04/2024

Acknowledgments

programs). Remedies and complaint filing deadlines vary by program or incident. Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English. To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by:(1) mail: U.S. Department of Agriculture Office of the Assistant Secretary for Civil Rights 1400 Independence Avenue, SW Washington, D.C. 20250-9410;(2) fax: (202) 690-7442; or(3) email: program.intake@usda.govUSDA is an equal opportunity provider, employer, and lender.

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	11/24/2024
Approved by	Suzanne Mayne-Kinney
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**