USDA Natural Resources Conservation Service

Ecological site R056BY104MN
Choppy Sands

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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 Choppy Sands ecological site is located on sandy uplands, primarily delta plains, which have been reworked by wind into dunes. The soils are very deep. The surface layer is typically fine sand. Soil on this site is excessively drained. The slopes of the dunes are highly variable; the slope range of the Choppy Sands site is typically 15 to 35 percent but slopes >35% may be included in some areas. The Sands site occurs on adjacent, less sloping (<15 percent), wind-worked areas and on more stable, sandy landscapes.

Associated sites

R056BY090MN	**Sands** This site occurs on more stable sand plains and on less sloping areas (<15% slope) of wind-worked sand plains. It is sand or loamy sand (fine to coarse sands) within a depth of 10 inches. The subsoil does not form a ribbon.
R056BY095MN	**Subirrigated** This site occurs in swales and blow-outs. It has redoximorphic features at a depth of 18 to 30 inches.
R056BY096MN	**Subirrigated Sands** This site occurs lower on the landscape – on flats. It has redoximorphic features at a depth of 30 to 40 inches. The subsoil does not form a ribbon.
R056BY102MN	**Wet Meadow** This site is in the bottom of some blowouts. It is poorly drained - a seasonal high water table is typically within a depth of 1.5 feet during the months of April through June; it may pond due to frozen ground in early spring. It has redoximorphic features within a depth of 18 inches. On this landscape, the site is non-saline.

Similar sites

R056BY090MN	**Sands** This site occurs on more stable sand plains and on less sloping areas (<15% slope) of wind-worked sand plains. It is sand or loamy sand (fine to coarse sands) within a depth of 10 inches. The subsoil does not form a ribbon.

Table 1. Dominant plant species

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

Physiographic features

This site occurs on sandy uplands, primarily delta plains, which have been reworked by wind into dunes. Slope typically ranges from 15 to 35 percent.

Table 2. Representative physiographic features

Landforms	(1) Dune (2) Delta plain
Flooding frequency	None
Ponding frequency	None
Elevation	229–451 m
Slope	15–35%
Ponding depth	0 cm
Water table depth	203 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

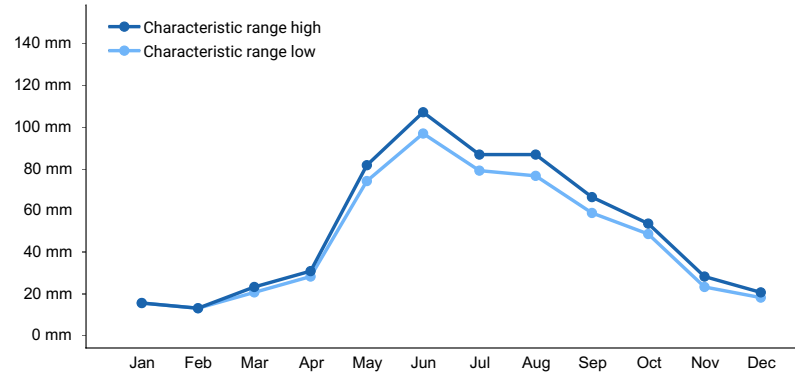


Figure 1. Monthly precipitation range

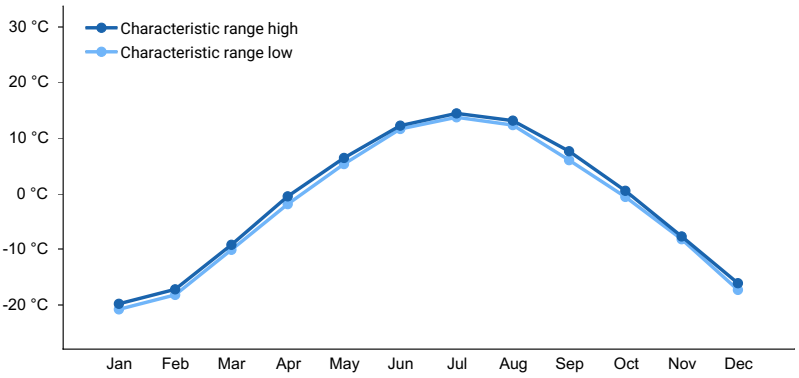


Figure 2. Monthly minimum temperature range

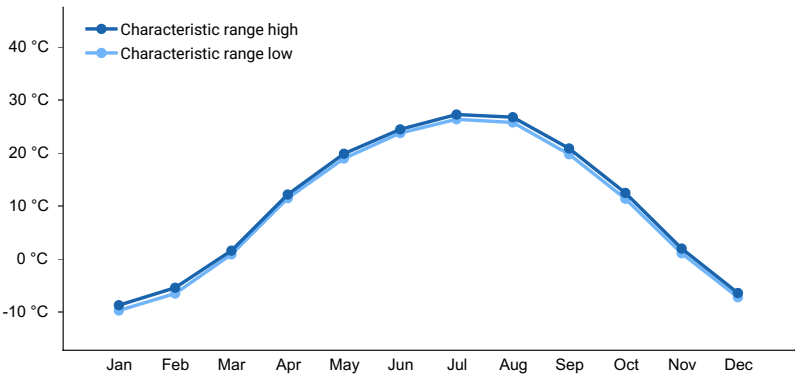


Figure 3. Monthly maximum temperature range

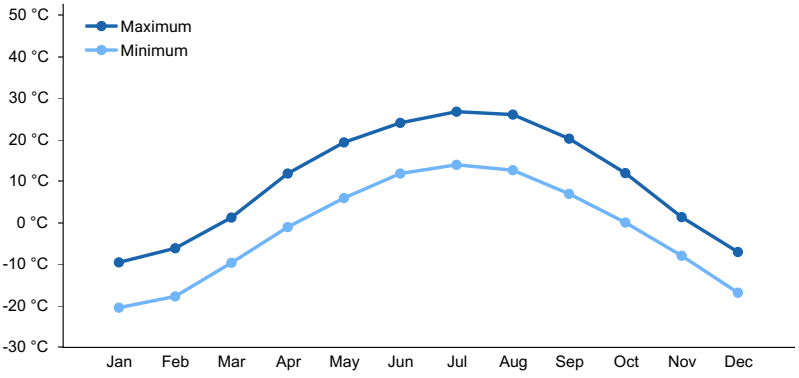


Figure 4. Monthly average minimum and maximum temperature

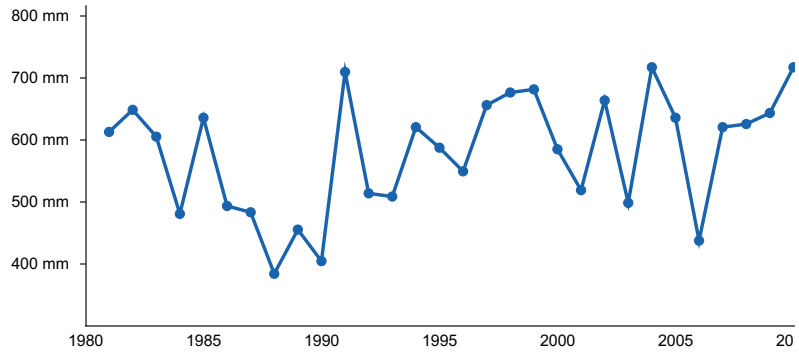


Figure 5. Annual precipitation pattern

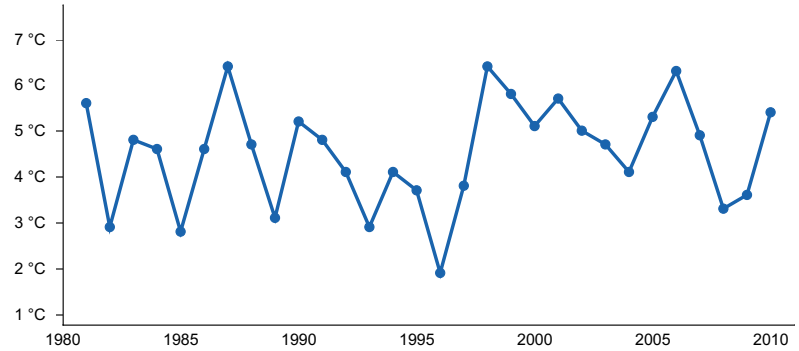


Figure 6. Annual average temperature pattern

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

This site does not receive additional water, either as runoff from adjacent slopes or from a seasonal high water table. Depth to the water table is deeper than 6 feet throughout the growing season. Surface infiltration is rapid. Saturated hydraulic conductivity through the profile is high. Water loss on this site occurs through percolation below the root zone and through evapotranspiration.

Wetland description

Not Applicable.

Soil features

Soils associated with Choppy Sands ES are in the Entisol order; they are classified further as Typic Udipsamments. These soils were developed under prairie vegetation. They formed in eolian sands. These soils are very deep and excessively drained. The common features of soils in this site are the coarse textures throughout and the wind-blown landform with dominant slopes exceeding 15 percent. The surface layer is typically fine sand. Some areas may have buried A horizons. The rest of the soil profile is typically fine sand, but sand is included.

It is not uncommon to have pedestaling of plants due to the inherent instability of the soils. Water flow paths are broken, irregular in appearance or discontinuous. There is a risk of rills and eventually gullies if vegetative cover is not adequate. Wind erosion is the greatest risk. Loss of the thin soil surface layer can result in a shift in species composition and/or production.

Major soil series correlated to the Choppy Sands site are: Serden.

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

Table 4. Representative soil features

Parent material	(1) Eolian sands
Surface texture	(1) Fine sand
Drainage class	Excessively drained
Permeability class	Rapid
Depth to restrictive layer	203 cm
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	5.08–9.4 cm
Soil reaction (1:1 water) (0-25.4cm)	6.1–7.8
Subsurface fragment volume <=3" (Depth not specified)	0%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

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 altering 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 three plant community phases.

Currently 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, quackgrass, and/or crested wheatgrass 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 to the three community phases in 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 no use and no fire (T2A).

State 3: Wooded State
This state historically existed as small patches of trees and/or shrubs 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. Two community phases have been identified and often result from extended periods of no use and no fire (T2A, T4A). Brush control (e.g. herbicide, mechanical, prescribed burning) may lead to State 2: Native/Invaded State (R3A). However, depending on the abundance of exotic grasses, brush control may need to be followed by a range planting to complete the restoration.

State 4: Invaded State. The threshold for this state is reached when the exotic cool-season grasses (e.g. Kentucky bluegrass, smooth brome, quackgrass, crested wheatgrass) exceed 30% of the plant community and native grasses represent less than 40% of the community. One 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 no 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 may be accomplished with the implementation of long-term prescribed grazing in conjunction with prescribed burning(R4A). This state may also transition to State 3: Wooded State during extended periods of no use and no fire (T4A).

State 5: Go-Back State often results from over-use with extended drought or human disturbance (e.g. off-road vehicle use) and consists of only one 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.

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..

Initially, due to extensive bare ground and a preponderance of shallow rooted annual plants 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).

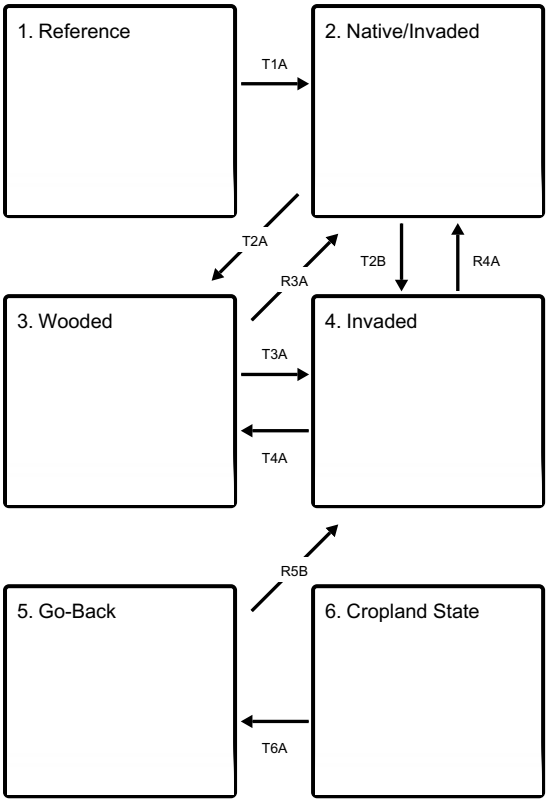
The following state and transition model diagram illustrates the common states, community phases, community pathways, transition and restoration pathways that can occur on the site. These are the most common plant community phases and states based on current knowledge and experience; changes may be made 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.

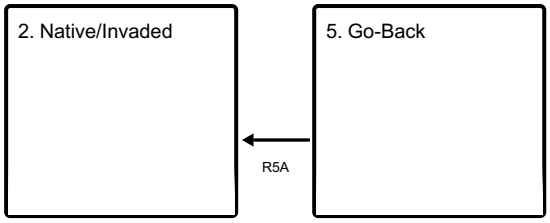
The plant community phase composition table(s) has been developed from the best available knowledge including research, historical records, clipping studies, and inventory records. As more data are collected, plant community species composition and production information may be revised.

State and transition model

Ecosystem states



States 2 and 5 (additional transitions)



T1A - Introduction of exotic species

T2A - No-use, no fire

T2B - Heavy season-long grazing, extended periods of no use, no fire

R3A - Brush control, perhaps followed by range planting

T3A - Brush control (i.e. herbicide, mechanical, prescribed burning)

R4A - Prescribed grazing and prescribed burning

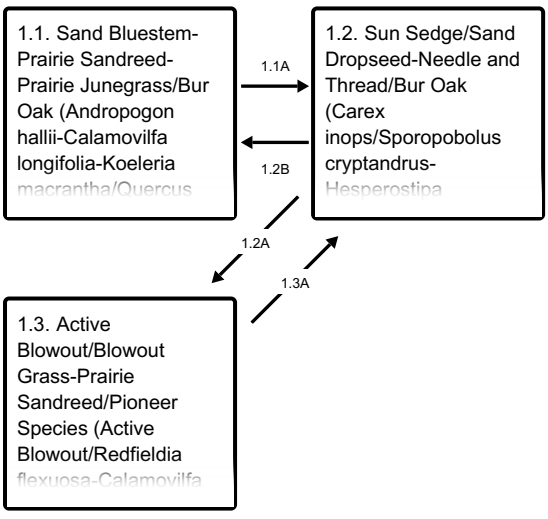
T4A - No-use, no fire

R5A - Successful range planting

R5B - Failed range planting

T6A - Cessation of annual cropping

State 1 submodel, plant communities



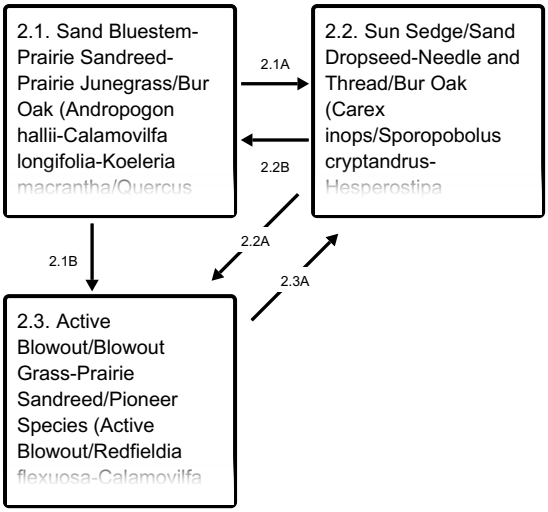
1.1A - Periods of below average precipitation

1.2B - Return to average precipitation and disturbance regime

1.2A - Periods of prolonged drought, excessive disturbance

1.3A - Return to average precipitation and disturbance regime

State 2 submodel, plant communities



2.1A - Season-long grazing and/or periods of below average precipitation

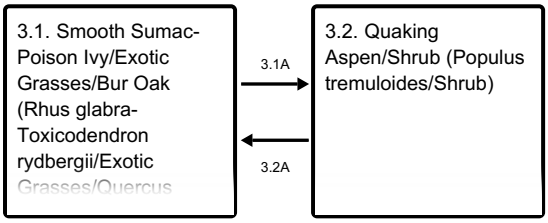
2.1B - Excessive disturbance

2.2B - Prescribed grazing and prescribed burning

2.2A - Periods of prolonged drought, excessive disturbance

2.3A - Return to average precipitation, prescribed grazing

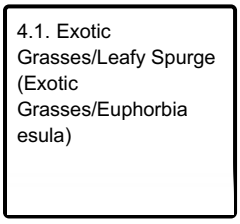
State 3 submodel, plant communities



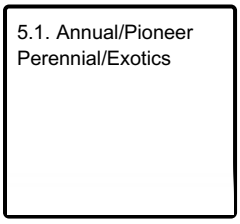
3.1A - No fire, no grazing

3.2A - Long-term absence of fire

State 4 submodel, plant communities



State 5 submodel, plant communities



State 1
Reference

Transition from Reference State (State 1) T1 to Native/Invaded State (State 2) This state represents the natural range of variability that dominated the dynamics of this ecological site. This state was dominated by warm-season grasses with minor amounts of cool-season grasses and forbs. 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. Mid and tall statured grass species would have declined with a corresponding increase in short statured warm-season grasses and cool-season grass-like species. Due to their fire tolerance, scattered, single stem oak trees would have been present on the site in all plant community phases. However, oak regeneration would have been reduced in the active blowout phase. Blowouts would have occurred as a result of prolonged drought and/or adjacent to areas of high animal impact, such as near perennial water sources. Slight shifts would have occurred in the timing of energy capture, hydrologic function and nutrient cycling between plant community phases 1.1 and 1.2 within State 1. Hydrologic function, energy capture and nutrient cycling would have been reduced in community phase 1.3 but would not have departed beyond the point of recovery.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- prairie sagewort (*Artemisia frigida*), shrub
- leadplant (*Amorpha canescens*), shrub
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- chokecherry (*Prunus virginiana*), shrub
- smooth sumac (*Rhus glabra*), shrub
- prairie rose (*Rosa arkansana*), shrub
- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- prairie Junegrass (*Koeleria macrantha*), grass
- needle and thread (*Hesperostipa comata*), grass
- sun sedge (*Carex inops ssp. heliophila*), grass
- blowout grass (*Redfieldia flexuosa*), grass
- prairie spiderwort (*Tradescantia occidentalis*), other herbaceous
- dotted blazing star (*Liatris punctata*), other herbaceous
- goldenrod (*Solidago*), other herbaceous
- field sagewort (*Artemisia campestris*), other herbaceous
- sunflower (*Helianthus*), other herbaceous

Community 1.1
Sand Bluestem-Prairie Sandreed-Prairie Junegrass/Bur Oak (Andropogon hallii-Calamovilfa longifolia-Koeleria macrantha/Quercus macrocarpa)

This community phase was the most dominant both temporally and spatially. Tall statured warm-season grasses such as sand bluestem and prairie sandreed would have been co-dominant with mid statured warm-season and cool-season grasses such as needle and thread, porcupinegrass, and little bluestem. Other grasses and grass-like species would have included sideoats grama, Canada wildrye, sand dropseed, prairie Junegrass, blue grama, and sun sedge. A variety of perennial forbs including prairie spiderwort, dotted blazing star, goldenrod, field sagewort, hairy false goldenaster, silky prairie clover, and sunflower were present. Shrubs included prairie sagewort, leadplant, Saskatoon serviceberry, chokecherry, smooth sumac, and prairie rose. Single stemmed bur oak trees would have been scattered across the site with oak mottes (a grove or clump of trees) occurring on some north facing slopes. Due to a diverse assemblage of plants, both rhizomatous and bunchgrasses, and presence of plant litter, this community would have been characterized by high infiltration, little runoff, and high drought tolerance. Annual production varied from about 1500-2700 pounds per acre with grasses and grass-likes, forbs, shrubs, and trees contributing about 80%, 10%, 7%, and 3% respectively. Both warm-season grasses and cool-season grasses were well represented in the community, and as a result production was 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	1457	2037	2617
Shrub/Vine	112	177	241
Forb	112	141	168
Total	**1681**	**2355**	**3026**

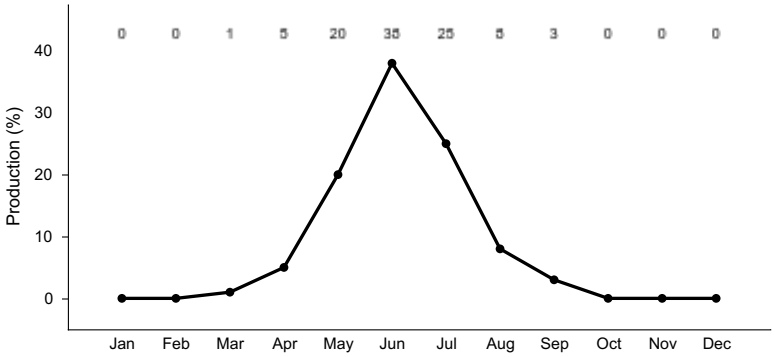


Figure 8. Plant community growth curve (percent production by month). ND5604, Red River Valley of the North, warm-season dominant, cool-season sub-dominant.. Warm-season dominant, cool-season sub-dominant..

Community 1.2
Sun Sedge/Sand Dropseed-Needle and Thread/Bur Oak (Carex inops/Sporopobolus cryptandrus-Hesperostipa comata/Quercus macrocarpa)

Grasses and grass-like species would have still dominated this phase, but the overall productivity of these species would have been reduced while forbs would have increased. Needle and thread, blue grama, sand dropseed, and sedges would have increased. Prairie sandreed and the bluestems would have decreased but still would have been present. Forb species such as field sagewort, goldenrod, Cuman ragweed, common yarrow, and upright prairie coneflower would have increased. Regeneration of bur oak was reduced. The shift to the shallower rooted, short statured blue grama and sedges, coupled with an increase in bare ground, resulted in higher soil surface temperatures as compared to Community Phase 1.1. Due to soil texture, infiltration rates would have been similar to Community Phase 1.1. Annual production would have slightly reduced compared to that of Community Phase 1.1.

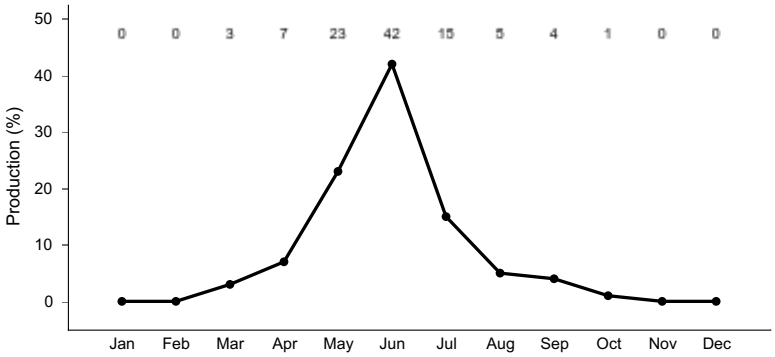


Figure 9. Plant community growth curve (percent production by month). ND5602, Red River Valley of the North, cool-season dominant, warm-season sub-dominant.. Cool-season dominant, warm-season sub-dominant..

Community 1.3
Active Blowout/Blowout Grass-Prairie Sandreed/Pioneer Species (Active Blowout/Redfieldia flexuosa-Calamovilfa longifolia/Pioneer Species)

This plant community phase was not stable. It consisted of bare areas that were continually eroded by wind. Vegetation was spare and scattered. Patches of sand bluestem and prairie sandreed would have been scattered across the site with blowout grass and other pioneer perennial and annual species such as mat sandbur and

common sunflower comprising the majority of the vegetation. Active wind erosion was very evident with soil deposition on leeward side of blowouts common. Excessive soil erosion in isolated instances may have resulted in a change in ecological site depending upon depth to water table. As erosion progressed, Subirrigated Sands and/or Subirrigated ecological sites may have developed within the Choppy Sands ecological site complex. Annual production and plant litter would have been greatly reduced as compared to Plant Community Phase 1.1, with bare ground exceeding 90 percent.

Pathway 1.1A
Community 1.1 to 1.2

Community Phase Pathway 1.1 to 1.2 occurred during periods of below average precipitation which may have been intensified by repeated heavy grazing, either due to proximity to water or following short term fire intervals followed by intense grazing. The competitive advantage shifted to the more grazing tolerant mid statured bunchgrasses such as needle and thread and sand dropseed, short statured grass-likes, and warm-season short statured grasses like blue grama.

Pathway 1.2B
Community 1.2 to 1.1

Community Phase Pathway 1.2 to 1.1 occurred with a return to average precipitation patterns, grazing and fire regime which allowed for the recovery of tall statured warm-season species and mid statured warm-season and cool-season bunch grasses. As the plant community recovered, basal gaps would have decreased, and plant litter would have increased.

Pathway 1.2A
Community 1.2 to 1.3

Community Phase Pathway 1.2 to 1.3 occurred with excessive disturbances such as prolonged drought, wildlife trailing or burrowing, or heavy grazing by wildlife due to proximity to a perennial water source would have significantly reduced perennial plant cover, reduced soil surface cover, and increased basal gap distance. This, coupled with the repeated disturbances, would have increased the amount of soil erosion due to wind, resulting in a blowout condition. These blowouts may have been relatively small and isolated or, depending upon the extent of the disturbance mechanism (i.e. long-term drought), covered larger areas.

Pathway 1.3A
Community 1.3 to 1.2

Community Phase Pathway 1.3 to 1.2 occurred over several years of average or above average precipitation and a reduction or elimination of the disturbance resulting in an increase in sand bluestem, blowout grass, and pioneer annuals and perennials. This additional cover (plant litter and basal) would have altered the wind patterns at the soil surface as the pathway proceeded.

Context dependence. Return to average precipitation and disturbance regime

State 2
Native/Invaded

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. Production may, however, be expected to be similar to that of State 1: Reference State (i.e. 1500-2700 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

- bur oak (*Quercus macrocarpa*), tree
- prairie sagewort (*Artemisia frigida*), shrub
- chokecherry (*Prunus virginiana*), shrub
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- leadplant (*Amorpha canescens*), shrub
- prairie rose (*Rosa arkansana*), shrub
- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- needle and thread (*Hesperostipa comata*), grass
- prairie Junegrass (*Koeleria macrantha*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- blowout grass (*Redfieldia flexuosa*), grass
- prairie spiderwort (*Tradescantia occidentalis*), other herbaceous
- goldenrod (*Solidago*), other herbaceous
- sunflower (*Helianthus*), other herbaceous
- dotted blazing star (*Liatris punctata*), other herbaceous
- leafy spurge (*Euphorbia esula*), other herbaceous

Community 2.1
Sand Bluestem-Prairie Sandreed-Prairie Junegrass/Bur Oak (Andropogon hallii-Calamovilfa longifolia-Koeleria macrantha/Quercus macrocarpa)

This Community Phase is similar to Community Phase 1.1 but has been colonized by exotic cool-season grasses, often Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass. However, these exotics are present in smaller amounts with the community still dominated by native grasses. Also, due to the altered fire regime, oak mottes on north facing slopes have increased in size and canopy cover. Annual production may be comparable to that of Community Phase 1.1 (1500-2700 pounds per acre). However, as the exotic cool-season grasses increase, peak production will shift to earlier in the growing season. This plant community phase is described in the “Plant Community Composition and Group Annual Production” portion of this ecological site description.

Table 6. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1524	2037	2544
Shrub/Vine	45	141	241
Forb	112	177	241
Total	**1681**	**2355**	**3026**

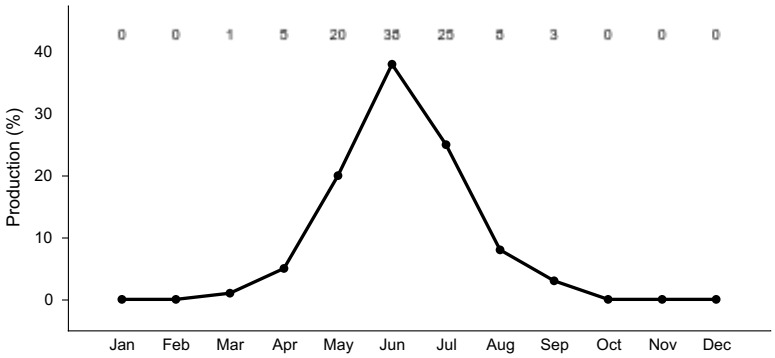


Figure 11. Plant community growth curve (percent production by month). ND5604, Red River Valley of the North, warm-season dominant, cool-season sub-dominant.. Warm-season dominant, cool-season sub-dominant..

Community 2.2
Sun Sedge/Sand Dropseed-Needle and Thread/Bur Oak (Carex inops/Sporopobolus cryptandrus-Hesperostipa comata/Quercus macrocarpa)

This community phase is similar to Community Phase 1.2 but has now been colonized by exotic cool-season grasses, often Kentucky bluegrass, smooth brome, crested wheatgrass, and/or quackgrass. These exotics are, however, present in smaller amounts with the community still dominated by native grasses. This community phase is often dispersed throughout a pasture in an overgrazed/undergrazed pattern, typically referred to as patch grazing. Some overgrazed areas will exhibit the impacts of heavy use, while the ungrazed areas will have a build-up of litter and increased plant decadence. This is a typical pattern found in properly stocked pastures grazed season-long. As a result, Kentucky bluegrass tends to increase more in the undergrazed areas while the more grazing tolerant short statured species such as blue grama, and sedges increase in the heavily grazed areas. If present, Kentucky bluegrass may increase under heavy grazing. A shift to shallower rooted and short statured species, coupled with an increase in bare ground, results in higher soil surface temperatures compared to Community Phase 2.1. Infiltration rates would be similar, as would the timing of plant production. Annual plant production, however, is slightly reduced.

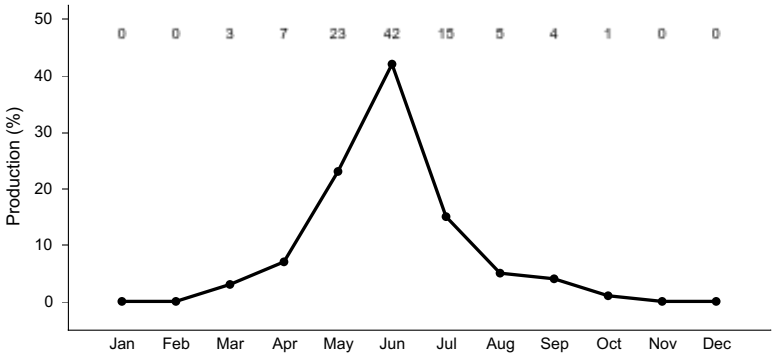


Figure 12. Plant community growth curve (percent production by month). ND5602, Red River Valley of the North, cool-season dominant, warm-season sub-dominant.. Cool-season dominant, warm-season sub-dominant..

Community 2.3
Active Blowout/Blowout Grass-Prairie Sandreed/Pioneer Species (Active Blowout/Redfieldia

flexuosa-Calamovilfa longifolia/Pioneer Species)

This community phase is similar to Community Phase 1.3 but typically has been colonized by exotic cool-season grasses, often Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass. However, these exotics are present in smaller amounts with the community still dominated by native grasses. Leafy spurge is also an exotic of concern. This plant community may be characterized by “blowouts” (i.e. active dunes and/or denuded areas caused by wind erosion). Active wind erosion is conspicuous with soil deposition on the leeward side of the “blowouts.” It is unstable and generally occupies small, isolated areas (e.g. 2 acres or less), but can increase to become more extensive. Vegetation consists of sparse and scattered patches of sand bluestem and prairie sandreed along with blowout grass and other pioneer perennial and annual species (e.g. mat sandbur). Exotic forbs such as leafy spurge may also be present.

Pathway 2.1A
Community 2.1 to 2.2

Community Phase Pathway 2.1 to 2.2. This pathway occurs with season-long grazing and/or periods of below average precipitation. Season-long grazing will shift the competitive advantage away from the tall warm-season rhizomatous grasses and mid statured warm-season and cool-season grasses to more grazing tolerant short statured grasses, grass-likes and forbs. Periods of below average precipitation will intensify the impact of the grazing and further facilitate this transition. Prolonged periods of drought would also result in this shift, with or without the grazing pressure.

Pathway 2.1B
Community 2.1 to 2.3

Community Phase Pathway 2.1 to 2.3. Excessive disturbance such as that related to off-road vehicle use or livestock trailing that removes plant cover resulting in a direct shift to plant community phase 2.3.

Pathway 2.2B
Community 2.2 to 2.1

Community Phase Pathway 2.2 to 2.1 is initiated by implementation of prescribed grazing management which includes adequate recovery periods following each grazing event and stocking levels which match the available resources. If properly implemented, this will shift the competitive advantage away from the introduced cool-season species and back to the tall statured warm-season rhizomatous grasses and mid statured warm-season and cool-season grasses. The addition of properly timed prescribed burning may expedite this shift.

Conservation practices

Prescribed Burning

Pathway 2.2A
Community 2.2 to 2.3

Community Phase Pathway 2.2 to 2.3 occurs with excessive disturbances such as livestock trailing/loafing due to proximity to a perennial water source, or off-road vehicle use, and/or prolonged drought which would significantly reduce perennial plant cover, reduce soil surface cover, and increase basal gaps. This, coupled with the repeated disturbances, increases the amount of wind erosion resulting in a blowout condition.

Pathway 2.3A
Community 2.3 to 2.2

Community Phase Pathway 2.3 to 2.2 occurs with return to average precipitation and the implementation of prescribed grazing management which includes adequate recovery periods following each grazing event and stocking levels which match the available resources will allow the remaining vegetation to recolonize and stabilize the site. Depending on the level of grazing management, fencing, seeding, mulching and complete deferment of the site for a couple of growing seasons may be necessary to speed the transition. Variation in seasonal precipitation may speed or delay recovery.

Conservation practices

Prescribed Grazing

State 3
Wooded

This state historically existed as small patches of trees and/or shrubs scattered across the site, particularly when close to wooded areas where trees and shrubs could have encroached onto the site vegetatively (e.g. rhizomes, root sprouts) or provided a seed source for colonization of the site. Variations in fire frequency enabled woody plant species in some areas (i.e. period of infrequent fire) to grow large enough to escape the next fire event. As trees increased in size, canopy cover increased which altered micro-climate and reduced fine fuel amounts resulting in reduced fire intensity and frequency. This would have been the primary pathway under the historic disturbance regime and would have resulted in a mosaic pattern of small wooded patches interspersed within herbaceous plant community phases. A marked increase in non-use management and active fire suppression since European influence has enabled this state to expand and become more widespread. Smooth sumac or poison ivy often initially become the dominant shrubs within the herbaceous portion of the site. Remnant warm-season and cool-season grasses and forbs are still found within these shrubs but in reduced amounts due to increased shading. Kentucky bluegrass is often present but may or may not be the dominant herbaceous species. Chokecherry and Saskatoon serviceberry thickets become more common near the edges of the bur oak mottes as do young trees such as green ash and hackberry.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- quaking aspen (*Populus tremuloides*), tree
- smooth sumac (*Rhus glabra*), shrub
- western poison ivy (*Toxicodendron rydbergii*), shrub
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- chokecherry (*Prunus virginiana*), shrub
- eastern redcedar (*Juniperus virginiana*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass
- needle and thread (*Hesperostipa comata*), grass
- sun sedge (*Carex inops ssp. heliophila*), grass
- leafy spurge (*Euphorbia esula*), other herbaceous
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous
- field sagewort (*Artemisia campestris*), other herbaceous
- white sagebrush (*Artemisia ludoviciana*), other herbaceous

Community 3.1
Smooth Sumac-Poison Ivy/Exotic Grasses/Bur Oak (Rhus glabra-Toxicodendron rydbergii/Exotic Grasses/Quercus macrocarpa)

This plant community phase represents the shift from a herbaceous dominated plant community with scattered bur oak and oak mottes to one dominated by shrubs such as smooth sumac or poison ivy with a herbaceous understory dominated by Kentucky bluegrass and leafy spurge. Remnant native grasses and grass-likes would include sand dropseed, needle and thread, blue grama, and sun sedge. Forbs would include Cuman ragweed, field sagewort, and white sagebrush. As the canopy cover of this shrub layer increases, the herbaceous plant community shifts from the remnant warm-season and cool-season native species to the more shade tolerant Kentucky bluegrass. Existing bur oak mottes would increase in size as shrubs such as Saskatoon serviceberry, chokecherry, and western snowberry (usually associated with the exterior fringe of the oak motte) expand outward into the adjacent herbaceous dominated plant community. As the shrub component increases, herbaceous production declines. This, combined with the shading effect of the shrubs, limits the effectiveness of prescribed burning as a restoration tool.

Community 3.2
Quaking Aspen/Shrub (Populus tremuloides/Shrub)

Once established, the quaking aspen's fast growth and clonal expansion often enables it to out-compete slower growing trees such as bur oak. Red cedar and buckthorn may invade the site. Quaking aspen may also encroach onto the site from adjacent Subirrigated Sands and Subirrigated ecological sites.

Pathway 3.1A
Community 3.1 to 3.2

Community Phase Pathway 3.1 to 3.2 results from extended periods of no fire and no grazing. The lack of disturbance, primarily fire, shifts the competitive advantage to the taller, fast growing tree species such as quaking aspen. As the quaking aspen canopy increases, shade tolerant understory species increase. Increased canopy cover also serves to further decrease fire intensity and frequency.

Pathway 3.2A
Community 3.2 to 3.1

Community Phase Pathway 3.2 to 3.1 occurs with long-term absence of fire. Quaking aspen becomes decadent, resulting in a more open canopy which shifts the plant community towards 3.1.

State 4
Invaded

This state is often characterized by an almost total dominance of Kentucky bluegrass and leafy spurge or perhaps other exotic cool-season grasses (e.g. quackgrass, smooth brome, crested wheatgrass) and leafy spurge. Remnant native species may still be found on the site but in only minor amounts. 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 2300-3300 pounds per acre with the exotic cool-season grasses accounting for the bulk of the production.

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

- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- crested wheatgrass (*Agropyron cristatum*), grass
- quackgrass (*Elymus repens*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass
- leafy spurge (*Euphorbia esula*), other herbaceous

Community 4.1
Exotic Grasses/Leafy Spurge (Exotic Grasses/Euphorbia esula)

This community phase is recognized by the dominance of exotic cool-season grasses and leafy spurge. Kentucky bluegrass if often the major exotic cool-season grass, but other common exotic cool-season grasses that invade the site include smooth brome, quackgrass, and crested wheatgrass. The lack of disturbance allows plant litter amounts to increase, further shifting the competitive advantage to these exotic species. Tall, mid and short statured warm-season and cool-season native species begin to decline until they are completely displaced. Research would indicate that leafy spurge alters soil microbiology in a manner which inhibits the growth of native species. This effectively reduces any potential for restoration to a native dominated plant community without very significant intervention. Compared to State 1: Reference State, herbaceous production has declined, and peak production has shifted to early spring through early summer. Plant diversity is also reduced. However, infiltration and runoff remain much the same.

State 5
Go-Back

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 overgrazing with extended drought or human disturbance (e.g. off-road vehicle use). 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

- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- crested wheatgrass (*Agropyron cristatum*), grass
- leafy spurge (*Euphorbia esula*), other herbaceous

Community 5.1
Annual/Pioneer Perennial/Exotics

This is highly variable plant community 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 overgrazing with extended drought or human disturbance (e.g. off-road vehicle use). 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.

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 brome, 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 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. Complete rest from grazing and elimination of fire are the two major contributors to this transition. Removal of these two disturbances shifts the competitive advantage within the herbaceous component of the plant community to exotic species such as Kentucky bluegrass and leafy spurge. The lack of repeated fire events permits shrubs such as smooth sumac, poison ivy, and/or chokecherry to expand from the edges of oak mottes into the adjacent herbaceous communities. Once established, this facilitates further expansion of the tree and shrub components. As shrub and tree canopy cover increases, the potential for disturbance by fire decreases due to lack of rime fuel and reduction of fire behavior.

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 T2B
State 2 to 4

The Transition from State 2: Native/Invaded State to State 4: Invaded State occurs with heavy season-long grazing or perhaps non-use. It can also occur with extended periods of no use and no fire. Leafy spurge is a frequent invader of the site. As leafy spurge becomes established on the site, it limits use by livestock and changes the micro-climate at the soil surface, facilitating a shift from the native herbaceous species to a community dominated by introduced grass and forb species. It is speculated the application of certain herbicides in an effort to control leafy spurge may facilitate an increase in Kentucky bluegrass.

Restoration pathway R3A
State 3 to 2

This restoration pathway from State 3: Wooded State to State 2: Native/Invaded State can be accomplished with brush control. Initial use of herbicides and/or mechanical brush control to reduce smooth sumac and other shrubs will permit adequate fine fuel loads to establish, permitting the application of prescribed fire to further control sprouting shrubs species. However, depending upon level of remnant native grasses and forbs, a range planting may also be necessary to re-establish the herbaceous plant community. 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 Grazing
Invasive Plant Species Control

Transition T3A
State 3 to 4

This transition from State 3: Wooded State to State 4: Invaded State can be accomplished with brush control. Initial use of herbicides and/or mechanical brush control to reduce smooth sumac and other shrubs will permit adequate fine fuel loads to establish, permitting the application of prescribed fire to further control sprouting shrubs species.

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.

Transition T4A
State 4 to 3

This Transition from State 4: Invaded State to State 3: Wooded State occurs during periods of no use and no fire. This enables shrubs such as smooth sumac and poison ivy to expand from the edges of bur oak mottes into the adjacent herbaceous communities. Once established, this facilitates further expansion of the tree and shrub components. As shrub and tree canopy cover increases, the potential for disturbance by fire decreases due to lack

of fine fuels and reduction in fire behavior.

Restoration pathway R5A
State 5 to 2

This Restoration from State 5: Go-Back State to 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 3: Invaded State.

Transition T6A
State 6 to 5

T6A transitional pathway is highly variable depending on the level and duration of disturbance.

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**			353–588	
	sand bluestem	ANHA	*Andropogon hallii*	353–471	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	235–353	–
2	**Cool-Season Bunch**			118–353	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	235–353	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	24–71	–
	Canada wildrye	ELCA4	*Elymus canadensis*	24–47	–
3	**Mid Warm-Season**			235–353	
	little bluestem	SCSC	*Schizachyrium scoparium*	118–235	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	24–118	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	47–118	–
4	**Short Warm-Season**			24–118	
	blue grama	BOGR2	*Bouteloua gracilis*	47–118	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	0–71	–
5	**Other Native Grasses**			24–118	
	prairie Junegrass	KOMA	*Koeleria macrantha*	24–71	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	24–47	–
6	**Grass-likes**			118–235	
	Grass-like (not a true grass)	2GL	*Grass-like (not a true grass)*	24–118	–

	grass)				
	sun sedge	CAINH2	*Carex inops ssp. heliophila*	47–118	–
	Schweinitz's flatsedge	CYSC3	*Cyperus schweinitzii*	0–24	–
Forb					
7	**Forbs**			118–235	
	field sagewort	ARCA12	*Artemisia campestris*	24–71	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	24–71	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	24–71	–
	Forb, perennial	2FP	*Forb, perennial*	24–71	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	24–47	–
	silky prairie clover	DAVI	*Dalea villosa*	24–47	–
	smooth horsetail	EQLA	*Equisetum laevigatum*	24–47	–
	sanddune wallflower	ERCAC	*Erysimum capitatum var. capitatum*	24–47	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	24–47	–
	dotted blazing star	LIPU	*Liatris punctata*	24–47	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	24–47	–
	flat-top goldentop	EUGR5	*Euthamia graminifolia*	0–47	–
	common sunflower	HEAN3	*Helianthus annuus*	0–47	–
	goldenrod	SOLID	*Solidago*	0–47	–
	onion	ALLIU	*Allium*	0–24	–
	milkweed	ASCLE	*Asclepias*	0–24	–
	thymeleaf sandmat	CHSES	*Chamaesyce serpyllifolia ssp. serpyllifolia*	0–24	–
	hairy false goldenaster	HEVIV	*Heterotheca villosa var. villosa*	0–24	–
	hoary puccoon	LICA12	*Lithospermum canescens*	0–24	–
	Lewis flax	LILE3	*Linum lewisii*	0–24	–
	narrowleaf stoneseed	LIIN2	*Lithospermum incisum*	0–24	–
Shrub/Vine					
8	**Shrubs**			118–165	
	leadplant	AMCA6	*Amorpha canescens*	24–47	–
	prairie sagewort	ARFR4	*Artemisia frigida*	24–47	–
	Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	0–24	–
	hawthorn	CRATA	*Crataegus*	0–24	–
	western sandcherry	PRPUB	*Prunus pumila var. besseyi*	0–24	–
	chokecherry	PRVI	*Prunus virginiana*	0–24	–
	smooth sumac	RHGL	*Rhus glabra*	0–24	–
	currant	RIBES	*Ribes*	0–24	–
	prairie rose	ROAR3	*Rosa arkansana*	0–24	–
	American red raspberry	RUID	*Rubus idaeus*	0–24	–
	prairie willow	SAHU2	*Salix humilis*	0–24	–
	western snowberry	SYOC	*Symphoricarpos occidentalis*	0–24	–
	eastern poison ivy	TORA2	*Toxicodendron radicans*	0–24	–
	common pricklyash	ZAAM	*Zanthoxylum americanum*	0–24	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–24	–
Tree					

Tree					
9	**Trees**			24–71	
	quaking aspen	POTR5	*Populus tremuloides*	24–71	–
	bur oak	QUMA2	*Quercus macrocarpa*	24–71	–
	common hackberry	CEOC	*Celtis occidentalis*	0–24	–

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**			353–588	
	sand bluestem	ANHA	*Andropogon hallii*	353–471	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	235–353	–
2	**Cool-Season Bunch**			118–353	
	needle and thread	HECO26	*Hesperostipa comata*	235–353	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	24–71	–
	Canada wildrye	ELCA4	*Elymus canadensis*	24–47	–
3	**Mid Warm-Season**			235–353	
	little bluestem	SCSC	*Schizachyrium scoparium*	118–235	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	24–118	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	47–118	–
4	**Short Warm-Season**			24–118	
	blue grama	BOGR2	*Bouteloua gracilis*	47–118	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	0–71	–
5	**Other Native Grasses**			24–118	
	prairie Junegrass	KOMA	*Koeleria macrantha*	24–71	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	24–47	–
6	**Grass-likes**			118–235	
	Grass-like (not a true grass)	2GL	*Grass-like (not a true grass)*	24–118	–
	sun sedge	CAINH2	*Carex inops ssp. heliophila*	47–118	–
	Schweinitz's flatsedge	CYSC3	*Cyperus schweinitzii*	0–24	–
7	**Non-Native Grasses**			24–118	
	Kentucky bluegrass	POPR	*Poa pratensis*	24–118	–
Forb					
8	**Forbs**			47–235	
	field sagewort	ARCA12	*Artemisia campestris*	24–71	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	24–71	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	24–71	–
	Forb, perennial	2FP	*Forb, perennial*	24–71	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	24–47	–
	silky prairie clover	DAVI	*Dalea villosa*	24–47	–
	smooth horsetail	EQLA	*Equisetum laevigatum*	24–47	–
	sanddune wallflower	ERCAC	*Erysimum capitatum var. capitatum*	24–47	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	24–47	–

	[illegible]	[illegible]	*Helianthus pauciflorus*	[illegible]	
	dotted blazing star	LIPU	*Liatris punctata*	24–47	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	24–47	–
	flat-top goldentop	EUGR5	*Euthamia graminifolia*	0–47	–
	common sunflower	HEAN3	*Helianthus annuus*	0–47	–
	goldenrod	SOLID	*Solidago*	0–47	–
	onion	ALLIU	*Allium*	0–24	–
	milkweed	ASCLE	*Asclepias*	0–24	–
	thymeleaf sandmat	CHSES	*Chamaesyce serpyllifolia ssp. serpyllifolia*	0–24	–
	hairy false goldenaster	HEVIV	*Heterotheca villosa var. villosa*	0–24	–
	narrowleaf stoneseed	LIIN2	*Lithospermum incisum*	0–24	–
	large Indian breadroot	PEES	*Pediomelum esculentum*	0–24	–
9	**Non-Native Forbs**			24–118	
	leafy spurge	EUES	*Euphorbia esula*	24–118	–
Shrub/Vine					
10	**Shrubs**			118–235	
	leadplant	AMCA6	*Amorpha canescens*	24–47	–
	prairie sagewort	ARFR4	*Artemisia frigida*	24–47	–
	Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	0–24	–
	hawthorn	CRATA	*Crataegus*	0–24	–
	western sandcherry	PRPUB	*Prunus pumila var. besseyi*	0–24	–
	chokecherry	PRVI	*Prunus virginiana*	0–24	–
	smooth sumac	RHGL	*Rhus glabra*	0–24	–
	currant	RIBES	*Ribes*	0–24	–
	prairie rose	ROAR3	*Rosa arkansana*	0–24	–
	American red raspberry	RUID	*Rubus idaeus*	0–24	–
	prairie willow	SAHU2	*Salix humilis*	0–24	–
	western snowberry	SYOC	*Symphoricarpos occidentalis*	0–24	–
	western poison ivy	TORY	*Toxicodendron rydbergii*	0–24	–
	common pricklyash	ZAAM	*Zanthoxylum americanum*	0–24	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–24	–
Tree					
11	**Trees**			24–71	
	quaking aspen	POTR5	*Populus tremuloides*	24–118	–
	bur oak	QUMA2	*Quercus macrocarpa*	24–118	–
	common hackberry	CEOC	*Celtis occidentalis*	0–24	–

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.

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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	09/04/2024
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:**
