USDA Natural Resources Conservation Service

Ecological site R056BY091MN
Sandy

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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 Sandy ecological site is located on lake plains, delta plains, outwash plains, and beach ridges The soils are very deep. Surface and subsoil textures (to depth of more than 20 inches) typically are fine sandy loam to sandy loam. Soil on this site is moderately well drained drained. Slopes typically range from 0 to 2 percent.

Associated sites

R056BY087MN	**Limy Subirrigated** This site occurs lower on the landscape. The soil is highly calcareous in the upper part of the subsoil and has redoximorphic features at a depth of 18 to 30 inches. All textures are included in this site.
R056BY094MN	**Loamy** This site occurs on similar landscape positions. The surface and subsoil layers to a depth >20 inches form a ribbon 1 to 2 inches long.
R056BY095MN	**Subirrigated** This site occurs on concave flats and in shallow depressions which have occasional, brief ponding early in the growing season. It has redoximorphic features at a depth of 18 to 30 inches. It is >16 inches to a highly calcareous subsoil. All textures are included in this site.
R056BY090MN	**Sands** This site occurs on similar landscape positions. The soil does not form a ribbon between depths of 10 to 20 inches. Redoximorphic features, if present, are deeper than 40 inches.
R056BY096MN	**Subirrigated Sands** This site occurs on similar or slightly lower landscape positions. The soil does not form a ribbon above a depth of 20 inches. It has redoximorphic features within a depth of 40 inches.

Similar sites

R056BY090MN	**Sands** This site occurs on similar landscape positions. The soil does not form a ribbon between depths of 10 to 20 inches. Redoximorphic features, if present, are deeper than 40 inches.
R056BY094MN	**Loamy** This site occurs on similar landscape positions. The surface and subsoil layers to a depth >20 inches form a ribbon 1 to 2 inches long.
R056BY096MN	**Subirrigated Sands** This site occurs on similar or slightly lower landscape positions. The soil does not form a ribbon above a depth of 20 inches. It has redoximorphic features within a depth of 40 inches.

Table 1. Dominant plant species

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

Physiographic features

This site occurs on lake plains, delta plains, outwash plains, and beach ridges;

Table 2. Representative physiographic features

Landforms	(1) Lake plain > Beach ridge (2) Delta plain (3) Outwash plain
Runoff class	Negligible to low
Flooding frequency	None
Ponding frequency	None
Elevation	750–1,480 ft
Slope	0–2%
Ponding depth	0 in
Water table depth	24–60 in
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)	22-23 in
Frost-free period (actual range)	102-110 days
Freeze-free period (actual range)	132-137 days
Precipitation total (actual range)	22-24 in
Frost-free period (average)	106 days

Freeze-free period (average)	135 days
Precipitation total (average)	23 in

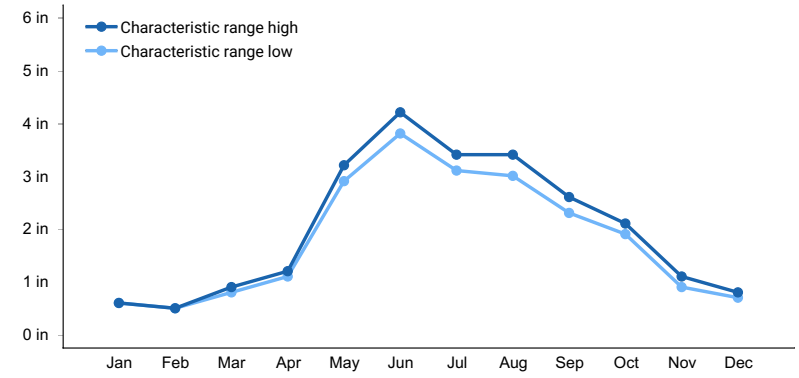


Figure 1. Monthly precipitation range

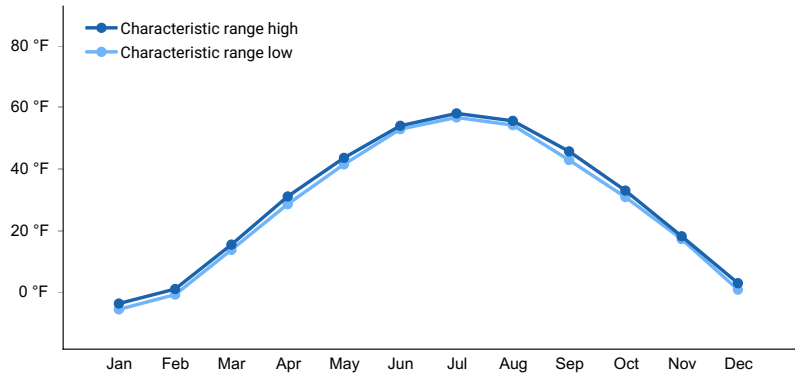


Figure 2. Monthly minimum temperature range

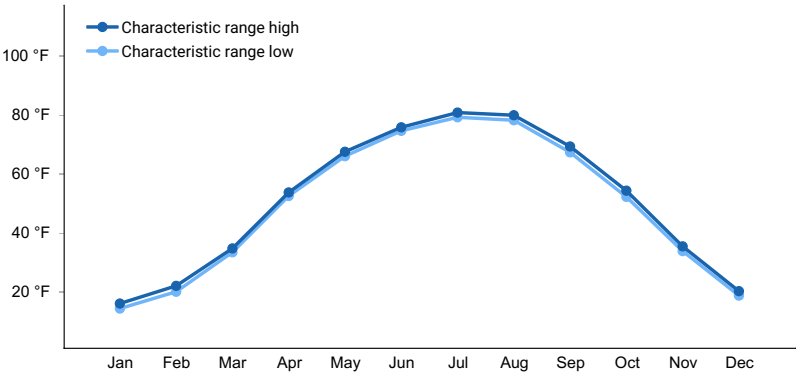


Figure 3. Monthly maximum temperature range

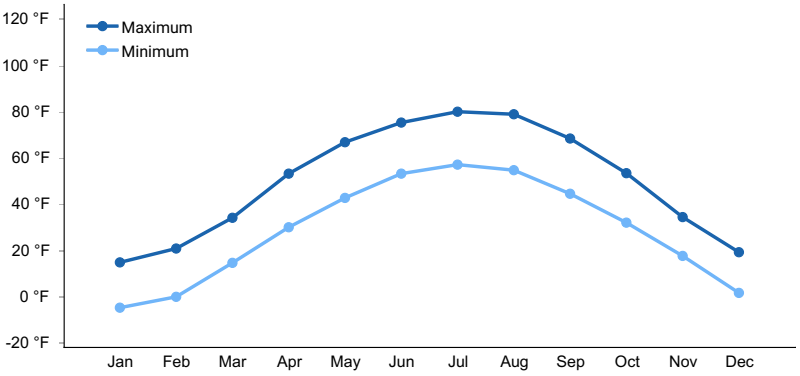


Figure 4. Monthly average minimum and maximum temperature

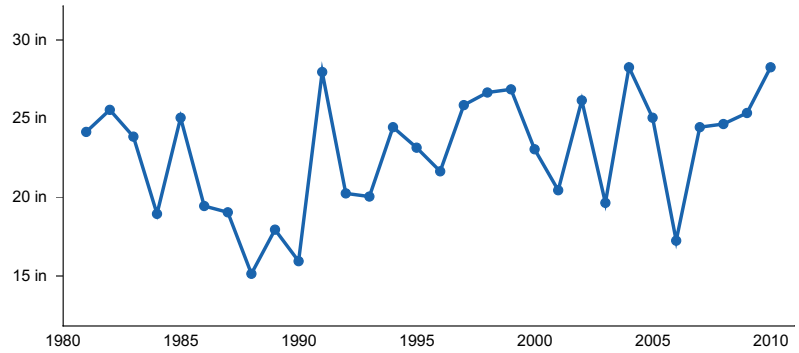


Figure 5. Annual precipitation pattern

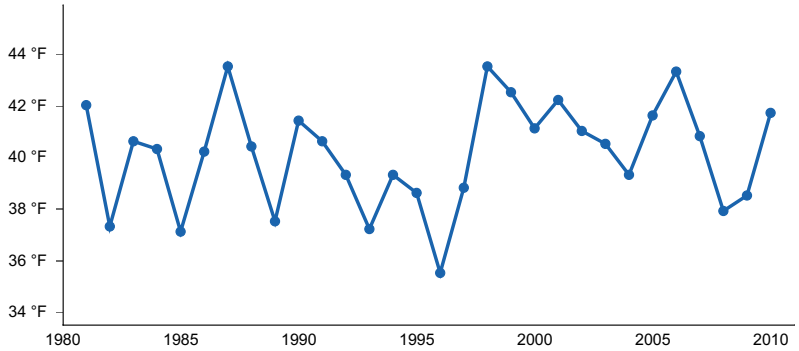


Figure 6. Annual average temperature pattern

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 significant additional water, either as runoff from adjacent slopes or from a seasonal high water table. Depth to the water table exceeds 2 feet in the spring and exceeds 5 feet in the summer months. Surface infiltration is moderate or moderately rapid. Water loss is through percolation below the root zone and through evapotranspiration.

Wetland description

Not Applicable,

Soil features

Soils associated with Sandy ES are typically in the Mollisol order. These soils were developed under prairie vegetation. The common features of soils in this site are the moderately coarse textures and a drainage class of moderately well - where present, redoximorphic features are deeper than 24 inches. The surface layer is most commonly fine sandy loam or sandy loam. The soils are very deep.

Major soil series correlated to the Sandy site are: Foxhome, Huot,

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) Glaciolacustrine deposits (2) Glaciofluvial deposits (3) Beach sand (4) Alluvium (5) Eolian deposits (6) Outwash (7) Lacustrine deposits
Surface texture	(1) Fine sandy loam (2) Sandy loam
Drainage class	Moderately well drained
Permeability class	Slow to rapid
Depth to restrictive layer	80 in
Soil depth	80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-60in)	3.1–6.5 in
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (0-40in)	1–24%
Subsurface fragment volume >3" (0-40in)	0–2%

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 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, under adverse impacts, may result in a slow decline in vegetative vigor and composition. However, under favorable conditions the botanical composition may resemble that prior to European influence.

Five vegetative states have been identified for the site (Reference, Native/Invaded, 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; they 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; it often resulted from colonization by exotic cool-season grasses such as Kentucky bluegrass, smooth brome, quackgrass, and/or perhaps 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 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. 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 3: Invaded State should be expected (T2A). 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.

State 3: 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 become 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 (R3A) may be accomplished with the implementation of long-term prescribed grazing in conjunction with prescribed burning.

State 4: 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 (R4A). Following planting, 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 3: Invaded State (R4B).

State 5: 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..

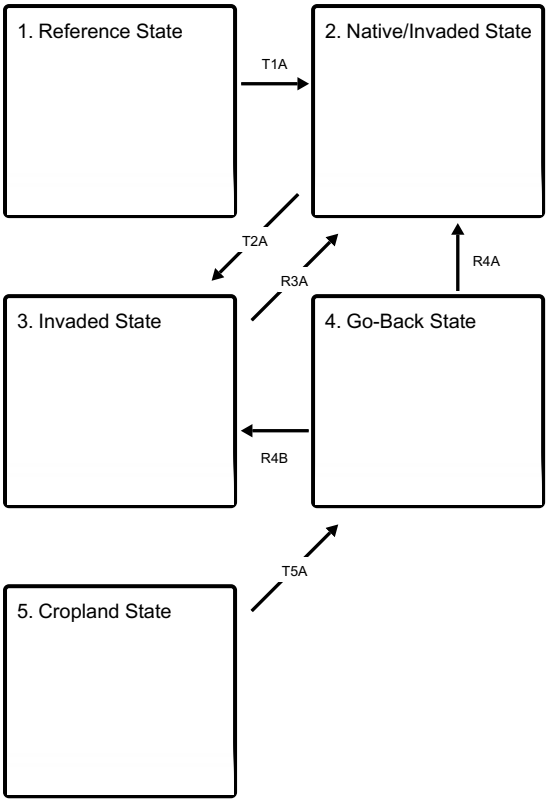
The following state and transition model diagram illustrate the common states, community phases, community pathways, transition and restoration pathways that can occur on the site. These are the most common plant community phases and states based on current knowledge and experience; changes may be made as more data are collected. Pathway narratives describing the site’s ecological dynamics reference various management practices (e.g. prescribed grazing, prescribed burning, 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; it should be developed by knowledgeable individuals and 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



T1A - Introduction of exotic cool-season grasses

T2A - Extended periods of non-use, or very light grazing, no fire

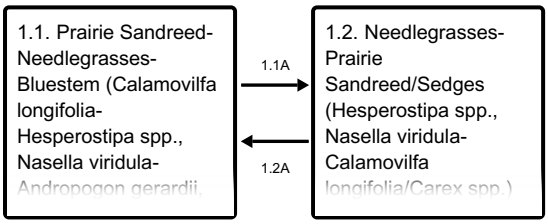
R3A - Long-term prescribed grazing with prescribed burning

R4A - Successful range seeding

R4B - Failed range seeding

T5A - Cessation of annual cropping

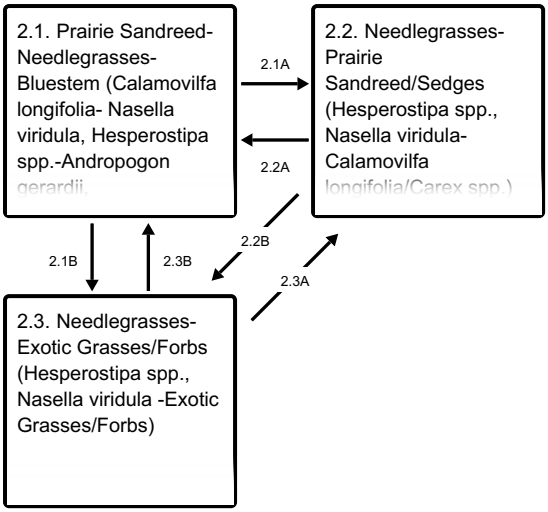
State 1 submodel, plant communities



1.1A - Long-term drought with or without heavy grazing

1.2A - Return to average precipitation

State 2 submodel, plant communities



2.1A - Long-term drought with or without heavy grazing

2.1B - Extended periods of non-use, or very light grazing, no fire

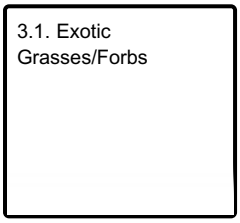
2.2A - Return to average precipitation and prescribed grazing and prescribed burning

2.2B - Extended periods of non-use, or very light grazing, no fire

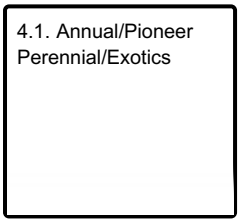
2.3B - Long term prescribed grazing with prescribed burning

2.3A - Long term prescribed grazing and prescribed burning

State 3 submodel, plant communities



State 4 submodel, plant communities



State 1
Reference State

This state represents 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.

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 condition is contingent upon a monitoring protocol to guide management.

Dominant plant species

- prairie sagewort (*Artemisia frigida*), shrub
- leadplant (*Amorpha canescens*), shrub
- prairie rose (*Rosa arkansana*), shrub
- white meadowsweet (*Spiraea alba*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- prairie sandreed (*Calamovilfa longifolia*), grass
- needle and thread (*Hesperostipa comata*), grass
- porcupinegrass (*Hesperostipa spartea*), grass
- green needlegrass (*Nassella viridula*), grass
- big bluestem (*Andropogon gerardii*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- purple prairie clover (*Dalea purpurea*), other herbaceous
- field sagewort (*Artemisia campestris*), other herbaceous
- Missouri goldenrod (*Solidago missouriensis*), other herbaceous
- upright prairie coneflower (*Ratibida columnifera*), other herbaceous
- longbract spiderwort (*Tradescantia bracteata*), other herbaceous

Community 1.1
Prairie Sandreed-Needlegrasses-Bluestem (Calamovilfa longifolia- Hesperostipa spp., Nasella viridula-Andropogon gerardii, Schizachyrium scoparium)

This community phase was historically the most dominant both temporally and spatially. It was dominated by tall warm-season and mid cool-season grasses such as prairie sandreed, needle and thread, porcupinegrass, green needlegrass, big bluestem, and little bluestem. Other grass and grass-likes species included sideoats grama, prairie Junegrass, western wheatgrass, slender wheatgrass, bearded wheatgrass, blue grama, and sedges. A variety of leguminous and non-leguminous perennial forbs were present but in small amounts. These commonly included purple prairie clover, field sagewort, Missouri and velvety goldenrod, hairy false goldenaster, upright prairie coneflower, and longbract spiderwort. Common shrubs often included prairie sagewort, leadplant, prairie rose, white meadowsweet, and western snowberry. Annual production may have varied from around 2200-3900 pounds per acre and consisted of about 85% graminoids, 10% forbs, and 5% shrubs. 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 is the reference plant community phase 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 (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2190	2937	3630
Forb	145	248	385
Shrub/Vine	65	116	185
Total	**2400**	**3301**	**4200**

Community 1.2
Needlegrasses-Prairie Sandreed/Sedges (Hesperostipa spp., Nasella viridula-Calamovilfa longifolia/Carex spp.)

This Community Phase resulted from long-term drought with or without heavy grazing, resulting in a decrease in prairie sandreed and bluestems with a corresponding increase in needlegrasses and sedges compared to Community Phase 1.1. Other grasses that may have increased include blue grama and sand dropseed. Forbs and shrubs such as silverleaf Indian breadroot, field sagewort, and prairie sagewort may also have noticeably increased. Annual production was likely somewhat reduced compared to that of Community Phase 1.1.

Pathway 1.1A

Community 1.1 to 1.2

Community Phase Pathway 1.1 to 1.2 occurred during long-term drought with or without heavy grazing. This resulted in an increase in needlegrasses (particularly needle and thread) and sedges with a corresponding decrease in prairie sandreed and bluestems.

Pathway 1.2A
Community 1.2 to 1.1

Community Phase Pathway 1.2 to 1.1 occurred with return to average precipitation leading to an increase in the bluestems and prairie sandreed with a corresponding decrease in in sedges and needlegrasses

State 2
Native/Invaded State

This State is generally similar to the State 1: Reference State but has now been colonized by the exotic cool-season grasses, often Kentucky bluegrass, smooth brome, quackgrass, and/or perhaps crested wheatgrass which are now present in small amounts. Although the state is still dominated by native grasses, an increase in the 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 3: Invaded State should be expected. Annual production of this state can be quite variable, in large part due to the proportion of exotic cool-season grasses. Annual production, however, may range from around 1400-2800 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 sandreed (*Calamovilfa longifolia*), grass
- needle and thread (*Hesperostipa comata*), grass
- porcupinegrass (*Hesperostipa spartea*), grass
- green needlegrass (*Nassella viridula*), grass
- sand bluestem (*Andropogon hallii*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- Kentucky bluegrass (*Poa pratensis*), grass

- smooth brome (*Bromus inermis*), grass
- purple prairie clover (*Dalea purpurea*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- Missouri goldenrod (*Solidago missouriensis*), other herbaceous
- sedge (*Carex*), other herbaceous
- white sagebrush (*Artemisia ludoviciana*), other herbaceous

Community 2.1
Prairie Sandreed-Needlegrasses-Bluestem (Calamovilfa longifolia- Nasella viridula, Hesperostipa spp.-Andropogon gerardii, Schizachyrium scoparium)

This Community Phase is similar to Community Phase 1.1 but has now been colonized by exotic cool-season grasses, often Kentucky bluegrass, smooth brome, quackgrass, and/or perhaps crested wheatgrass. However, these exotics are present in smaller amounts with the community still dominated by native grasses.

Community 2.2
Needlegrasses-Prairie Sandreed/Sedges (Hesperostipa spp., Nasella viridula-Calamovilfa longifolia/Carex spp.)

This Community Phase is similar to Community Phase 1.2 but has been colonized by exotic cool-season grasses, often Kentucky bluegrass, smooth brome, quackgrass, and/or perhaps crested wheatgrass. It results from long-term drought with or without the heavy grazing of Community Phase 2.1, which leads to a decrease in prairie sandreed and bluestems with a corresponding increase in needlegrasses (particularly needle and thread) and sedges. Other grasses that may show an increase include blue grama and sand dropseed. Forbs and shrubs such as silverleaf Indian breadroot, field sagewort, and prairie sagewort may also noticeably increase. 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 typically increases under heavy grazing.

Community 2.3
Needlegrasses-Exotic Grasses/Forbs (Hesperostipa spp., Nasella viridula -Exotic Grasses/Forbs)

This Community Phase occurs with extended periods of no use or very light grazing and no fire. As a result, there is a buildup of excessive mulch, a marked increase in the exotic cool-season grasses, and a decline in native grasses, particularly the warm-season species. White heath aster, goldenrods, and white sagebrush are among the common forbs of this community. Western snowberry is often a common shrub. This Community Phase is approaching the threshold leading to a transition to State 3: 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 3: Invaded State should be expected.

Pathway 2.1A
Community 2.1 to 2.2

Community Phase Pathway 2.1 to 2.2 occurs with long-term drought with or without heavy grazing. This results in a marked increase in the needlegrasses (particularly needle and thread) and sedges with a corresponding decrease in prairie sandreed and bluestems.

Pathway 2.1B
Community 2.1 to 2.3

Community Phase Pathway 2.1 to 2.3 occurs during extended periods of no use or very light grazing and no fire. This results in the buildup of excessive mulch and a marked increase in the exotic cool-season grasses with a corresponding decline in native grasses, particularly the warm-season species. A noticeable increase in some forbs

and shrubs also occurs and often includes white sagebrush, silverleaf Indian breadroot, common yarrow, goldenrods, and western snowberry.

Pathway 2.2A
Community 2.2 to 2.1

Community Phase Pathway 2.2 to 2.1 occurs with return to average precipitation with the implementation of prescribed burning and prescribed grazing. This results in a marked increase in prairie sandreed and the bluestems with a corresponding decrease in needlegrasses (particularly needle and thread) and sedges.

Pathway 2.2B
Community 2.2 to 2.3

Community Phase Pathway 2.2 to 2.3 occurs with extended periods of no use or very light grazing and no fire. This results in the buildup of excessive mulch, a marked increase in the exotic cool-season grasses, and a corresponding decline in native grasses, particularly the warm-season species. A noticeable increase in some forbs and shrubs also occurs and may include white sagebrush, silverleaf Indian breadroot, common yarrow, goldenrods, and western snowberry.

Pathway 2.3B
Community 2.3 to 2.1

Community Phase Pathway 2.3 to 2.1 occurs with the implementation of long term prescribed grazing and prescribed burning which results in a noticeable decrease in the exotic cool-season grasses along with a corresponding increase in the warm-season grasses, particularly prairie sandreed, big bluestem, and little bluestem. This pathway is basically the same as 2.3A, the difference being due to variations in the plant composition of Community Phase 2.3.

Pathway 2.3A
Community 2.3 to 2.2

Community Phase Pathway 2.3 to 2.2 occurs with the implementation of long-term prescribed grazing and prescribed burning which results in a noticeable decrease in the exotic cool-season grasses along with a corresponding increase in the warm-season grasses, particularly prairie sandreed, big bluestem, and little bluestem. This pathway is basically the same as 2.3B, the difference being due to variations in the plant composition of Community Phase 2.3.

State 3
Invaded State

This state is the result of invasion and dominance of the exotic cool-season grasses, commonly Kentucky bluegrass, smooth brome, quackgrass, and/or perhaps crested wheatgrass. These 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 and may include Cuman ragweed, white heath aster, and white sagebrush. Shrubs such as western snowberry, field sagewort, and prairie rose, however, may show marked increases. Once the state is well established, prescribed burning and prescribed 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 site may be in the range of 1900-3500 pounds per acre with the exotic cool-season grasses Kentucky bluegrass and smooth brome predominating.

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

- prairie rose (*Rosa arkansana*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- quackgrass (*Elymus repens*), grass
- leafy spurge (*Euphorbia esula*), other herbaceous
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- white sagebrush (*Artemisia ludoviciana*), other herbaceous

Community 3.1
Exotic Grasses/Forbs

This community phase is dominated by exotic cool-season sodgrasses such as Kentucky bluegrass, smooth brome, quackgrass, and/or crested wheatgrass often with a much-reduced forb and shrub component. Exotic forbs such as leafy spurge may also invade the site. Excessive accumulation of mulch may also be present, particularly when dominated by Kentucky bluegrass. Common forbs and shrubs often include Cuman ragweed, white heath aster, white sagebrush, field sagewort, prairie rose, and western snowberry.

State 4
Go-Back State

This state is highly variable depending on the level and duration of disturbance related to the T5A 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 needing control. Over time, however, the site will likely become dominated by the exotic cool-season grasses Kentucky bluegrass, smooth brome, crested wheatgrass, and/or quackgrass.

Characteristics and indicators. Tillage has destroyed the native plant community, altered soil structure and biology, reduced soil organic matter, and resulted in the formation of a tillage induced compacted layer which is restrictive to root growth. Noxious weeds, if present, will need to be managed.

Dominant plant species

- prairie rose (*Rosa arkansana*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- quackgrass (*Elymus repens*), grass
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- white sagebrush (*Artemisia ludoviciana*), other herbaceous
- field sagewort (*Artemisia campestris*), other herbaceous

Community 4.1
Annual/Pioneer Perennial/Exotics

his community phase is highly variable depending on the level and duration of disturbance related to the T5A 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, perhaps including noxious weeds (e.g. 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. Associated

forbs and shrubs often include Cuman ragweed, white heath aster, white sagebrush, field sagewort, prairie rose, and western snowberry.

State 5
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 perhaps crested wheatgrass. This transition was probably inevitable and corresponded to a decline in native warm-season and cool-season grasses. This transition was exacerbated by chronic season-long or heavy late season grazing. Complete rest from grazing and fire suppression may have also hastened this transition. The threshold between states is crossed when Kentucky bluegrass, smooth bromegrass, quackgrass, or other exotic species became established on the site.

Constraints to recovery. (i.e. variables or processes that preclude recovery of the former state). Current knowledge and technology will not facilitate a successful restoration to Reference State.

Transition T2A
State 2 to 3

This Transition from State 2: Native/Invaded State to State 3: Invaded State results from extended periods of no use or very light grazing with no fire but can also occur under other management. Exotic cool-season grasses such as quackgrass, Kentucky bluegrass, smooth brome, or perhaps 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, crested wheatgrass, and quackgrass.

Constraints to recovery. Variations in growing conditions (e.g. cool, wet spring) will influence effects of various management activities on exotic cool-season grass populations.

Restoration pathway R3A
State 3 to 2

This restoration pathway from State 3: 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 3.1. 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).

Restoration pathway R4A
State 4 to 2

This Restoration Pathway from State 3: Invaded State to the State 2: Native/Invaded State can be accomplished with a successful range planting. Following planting, 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, management objectives must include the maintenance of those species, the associated reference state functions, and continued treatment of exotic grasses. 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 grasses.

Context dependence. 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. Elevated soil nitrogen levels have been shown to benefit smooth brome and Kentucky bluegrass more than some native grasses. As a result, fertilization, exotic legumes in the seeding mix, and other techniques that increase soil nitrogen may promote smooth brome and Kentucky bluegrass invasion. The method or methods of herbaceous weed treatment will be site specific to each situation 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.

Restoration pathway R4B
State 4 to 3

A failed range planting and/or secondary succession will lead to State 3: 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 T5A
State 5 to 4

This transition from any plant community to State 4: Go-Back State. It is 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 tillage induced compaction, erosion, fertility, herbicide/pesticide carryover). Thus, soil conditions should be assessed when considering restoration techniques.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tall Warm-Season Grasses**			660–1815	
	big bluestem	ANGE	*Andropogon gerardii*	330–1155	–
	sand bluestem	ANHA	*Andropogon hallii*	0–660	–
	switchgrass	PAVI2	*Panicum virgatum*	165–495	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	99–495	–
	Indiangrass	SONU2	*Sorghastrum nutans*	33–330	–
2	**Cool-Season Grasses**			165–495	
	needle and thread	HECO26	*Hesperostipa comata*	66–495	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	66–495	–
	Canada wildrye	ELCA4	*Elymus canadensis*	0–99	–
3	**Mid Warm-Season Grasses**			330–660	
	little bluestem	SCSC	*Schizachyrium scoparium*	165–660	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	33–165	–
	prairie dropseed	SPHE	*Sporobolus heterolepis*	0–165	–
4	**Short Warm-Season Grasses**			66–165	
	blue grama	BOGR2	*Bouteloua gracilis*	33–165	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	0–99	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	33–66	–
	threeawn	ARIST	*Aristida*	0–33	–
5	**Other Native Grasses**			33–165	
	Graminoid (grass or grass-like)	2GRAM	*Graminoid (grass or grass-like)*	33–165	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	33–99	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	0–99	–
	fall rosette grass	DIWI5	*Dichanthelium wilcoxianum*	0–99	–
6	**Grass-Likes**			33–165	
	needleleaf sedge	CADU6	*Carex duriuscula*	33–165	–
	Grass-like (not a true grass)	2GL	*Grass-like (not a true grass)*	0–165	–
Forb					
7	**Forbs**			165–330	
	Forb (herbaceous, not grass nor grass-like)	2FORB	*Forb (herbaceous, not grass nor grass-like)*	33–165	–
	scurfpea	PSORA2	*Psoralidium*	33–66	–
	upright prairie coneflower	RACO3	*Ratibida columnifera*	33–66	–
	blackeved Susan	RUHI2	*Rudbeckia hirta*	0–66	–

	goldenrod	SOLID	*Solidago*	33–66	–
	white heath aster	SYER	*Symphyotrichum ericoides*	33–66	–
	American vetch	VIAM	*Vicia americana*	33–66	–
	field sagewort	ARCA12	*Artemisia campestris*	33–66	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	33–66	–
	purple prairie clover	DAPU5	*Dalea purpurea*	33–66	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	33–66	–
	blazing star	LIATR	*Liatris*	33–66	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	33–66	–
	soft-hair marbleseed	ONBEB	*Onosmodium bejariense var. bejariense*	0–66	–
	purple locoweed	OXLA3	*Oxytropis lambertii*	0–33	–
	beardtongue	PENST	*Penstemon*	0–33	–
	ticktrefoil	DESMO	*Desmodium*	0–33	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	0–33	–
	prairie fleabane	ERST3	*Erigeron strigosus*	0–33	–
	sand milkweed	ASAR	*Asclepias arenaria*	0–33	–
	milkvetch	ASTRA	*Astragalus*	0–33	–
	wavyleaf thistle	CIUN	*Cirsium undulatum*	0–33	–
	common yarrow	ACMI2	*Achillea millefolium*	0–33	–
	ragweed	AMBRO	*Ambrosia*	0–33	–
Shrub/Vine					
8	**Shrubs**			66–165	
	leadplant	AMCA6	*Amorpha canescens*	33–132	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–99	–
	rose	ROSA5	*Rosa*	33–66	–
	snowberry	SYMPH	*Symphoricarpos*	0–66	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–66	–

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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Contributors

Mark Hayek
Chuck Lura
Jeff Printz
Alan Gulsvig
Steve Sieler
David Dewald
Ezra Hoffman, Ecological Site Specialist, NRCS

Approval

Suzanne Mayne-Kinney, 9/04/2024

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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	09/27/2024
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:

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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):**

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

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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:**

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17. **Perennial plant reproductive capability:**
