USDA Natural Resources Conservation Service

Ecological site R056BY088MN
Loamy Overflow

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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 thesouth (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 Loamy Overflow ecological site is located on flood plains and foot slopes of lake plains, and till plain. The soils are very deep. Surface and subsoil textures range from fine sandy loam to silty clay (form a ribbon 1 to 2 inches long). Soil on this site are well drained. The site receives additional water as run-on from surrounding slopes or from frequent stream or river flooding. Slopes range from 3 to 15 percent.

Associated sites

R056BY087MN	**Limy Subirrigated** This site occurs somewhat lower on the landscape. It 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.
R056BY091MN	**Sandy** This site occurs on higher, linear slopes on lake plains and till plains mantled with moderately coarse textured eolian deposits – a run-off landscape position. The surface and subsoil layers form a ribbon <1 inch long.
R056BY094MN	**Loamy** This site typically occurs on linear slopes on till plains and lake plains on run-off landscape positions; it also occurs on terraces which are no longer impacted by frequent flooding. The surface and subsoil layers form a ribbon 1 to 2 inches long.
R056BY095MN	**Subirrigated** This site occurs on concave areas of flats and in shallow depressions with occasional, brief ponding. It has redoximorphic features at a depth of 18 to 30 inches. All textures are included in this site.

R056BY102MN	**Wet Meadow** This site occurs in depressions and flats on uplands; it also occurs on floodplains. 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; in depressions, it is frequently ponded (typically <1.5) in April and May. It typically has redoximorphic features within a depth of 18 inches. Some soils are highly calcareous. E.C. is <8 in the surface and subsoil layers. All textures are included in this site.

Similar sites

R056BY094MN	**Loamy** This site typically occurs on linear slopes on till plains and lake plains on run-off landscape positions; it also occurs on terraces which are no longer impacted by frequent flooding. The surface and subsoil layers form a ribbon 1 to 2 inches long.
R056BY095MN	**Subirrigated** This site occurs on concave areas of flats and in shallow depressions with occasional, brief ponding. It has redoximorphic features at a depth of 18 to 30 inches. All textures are included in this site.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Andropogon gerardii* (2) *Nassella viridula*

Physiographic features

This site occurs on areas that receive additional water as overflow of rivers and intermittent streams or runoff from adjacent slopes. It typically occurs on floodplains on lake plains and till plains of detla plains.

Table 2. Representative physiographic features

Landforms	(1) Lake plain > Flood plain (2) Delta plain > Till plain
Runoff class	Negligible to medium
Flooding duration	Very brief (4 to 48 hours)
Flooding frequency	None to occasional
Ponding frequency	None
Elevation	750–1,250 ft
Slope	3–15%
Ponding depth	0 in
Water table depth	36–60 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

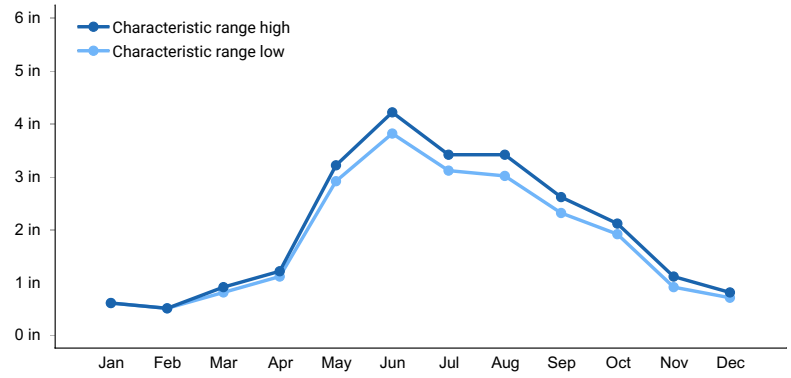


Figure 1. Monthly precipitation range

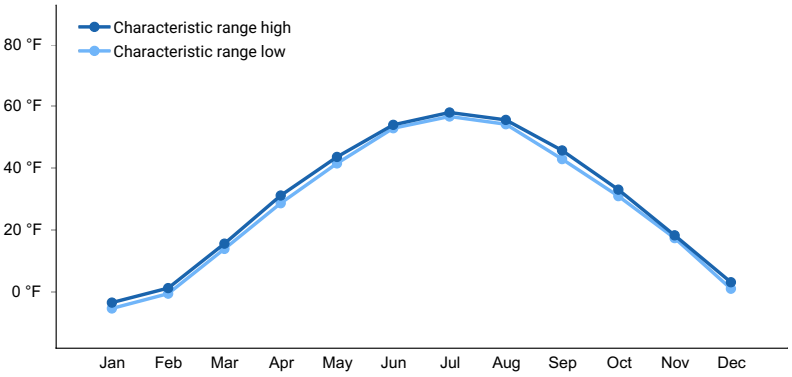


Figure 2. Monthly minimum temperature range

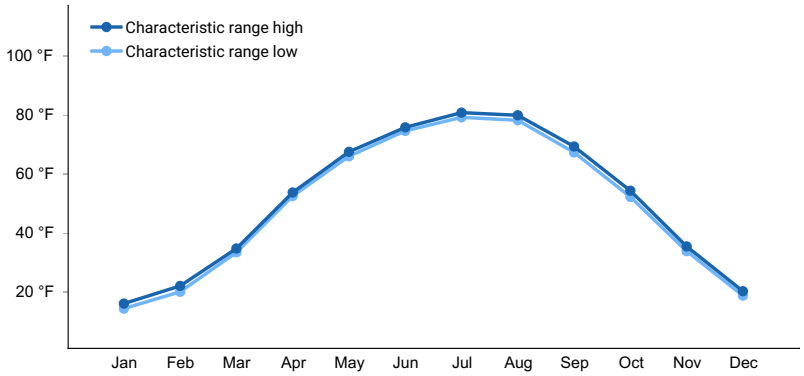


Figure 3. Monthly maximum temperature range

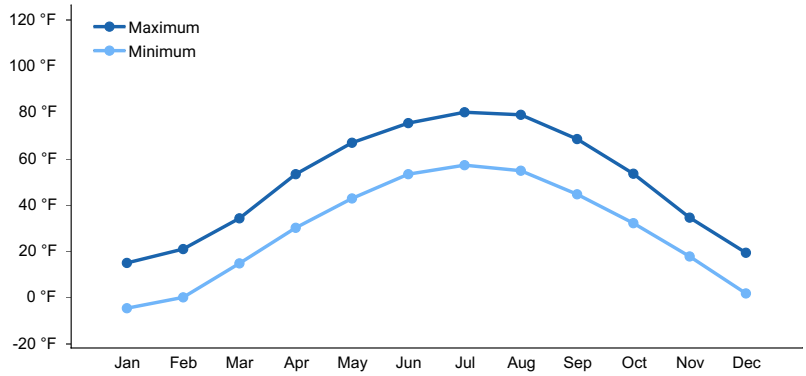


Figure 4. Monthly average minimum and maximum temperature

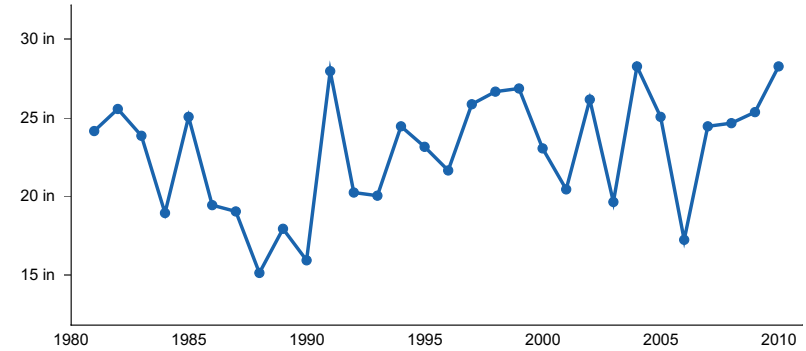


Figure 5. Annual precipitation pattern

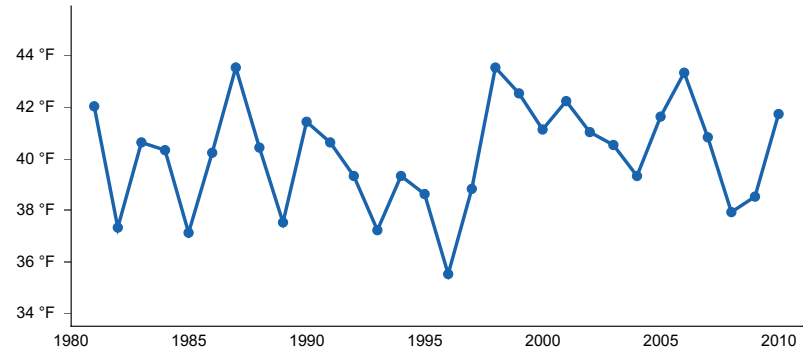


Figure 6. Annual average temperature pattern

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 receives significant additional water as overflow from rivers and intermittent streams or as run-on from adjacent slopes. Most of the additional water occurs during the months of April through June or after heavy summer thunderstorms. Ponding is typically none; however, after a heavy rainstorm, very brief ponding may occur in upland swales. Soils in this site have a seasonal high-water table as shallow 3 feet from April through June. Depth to the water table typically is deeper than 6 feet during the rest of the growing season. Surface infiltration is moderately slow to moderately rapid. Saturated hydraulic conductivity throughout the profile typically is moderately high or high; but in the substratum of some soils, it may be moderately low. Water loss is through evapotranspiration and percolation below the root zone.

Wetland description

Not applicable.

Soil features

Soils associated with Loamy Overflow ecological site (ES) are in the Mollisol and Entisol orders. These soils were developed under prairie vegetation. The soils are very deep. They are well drained – redoximorphic features, where present, are deeper than 3 feet. Surface and subsoil textures include loam, silt loam, , and fine sandy loam and may be stratified in some soils. Soil reaction typically is slightly acid to slightly alkaline (pH 6.6 to 8.4) in the surface layer and upper part of the subsoil.

Major soil series correlated to the Loamy Overflow site are: Fairdale, Swenoda, Gardena, and Svea.

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) Alluvium (3) Lacustrine deposits (4) Eolian deposits
Surface texture	(1) Silty clay (2) Loam (3) Silt loam (4) Fine sandy loam
Drainage class	Well drained
Permeability class	Moderately slow to moderately rapid
Depth to restrictive layer	80 in
Soil depth	80 in
Surface fragment cover <=3"	0–4%
Surface fragment cover >3"	0%
Available water capacity (0-60in)	5.2–8.7 in
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (0-40in)	0%
Subsurface fragment volume >3" (0-40in)	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; under adverse impacts, this 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.

Six vegetative states have been identified for the site (Reference, Native/Invaded, Invaded, Go-Back, Wooded, 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.

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). Extended periods of no use or very light grazing and no fire may lead to a transition to State 5: Wood State (T1B).

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, and/or quackgrass which have been particularly and consistently invasive under extended periods of no use and no fire. Other exotics, such as Canada thistle and leafy spurge, are also known to invade the site.
Three community phases have been identified for this state and are similar 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 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. This state may also transition to State 5: Wooded State during extended periods of no use or very light grazing and no fire (T2B).

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 increases and may 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. This state may also transition to State 5: Wooded State during extended periods of no use or very light grazing and no fire (T3A).

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, and/or quackgrass will likely predominate.

Initially, due to extensive bare ground and a preponderance of shallow rooted annual plants, infiltration is low; 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: 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. One community phase has been identified and often results from extended periods of no use or very light grazing and no fire (T1B, T2B).

Prescribed burning and/or chemical/mechanical brush management followed by a successful range planting may lead to State 2: Native/Invaded State (R5A). A failed range planting followed by secondary succession, however, may lead to a shift to State 3: Invaded State (R5B).

State 6: Cropland State. 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.

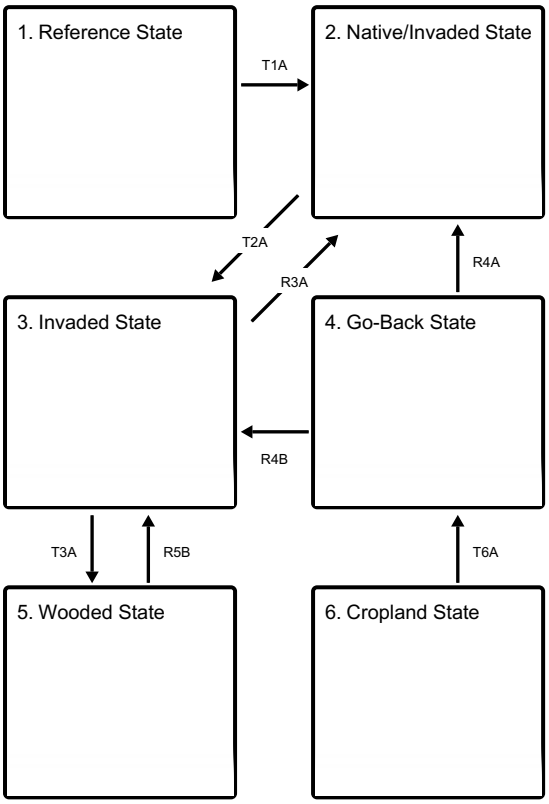
When the management goal is to maintain an existing plant community phase or restore to another phase within the same state, modification of existing management to ensure native species have the competitive advantage may be required. To restore a previous state, the application of two or more management 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.

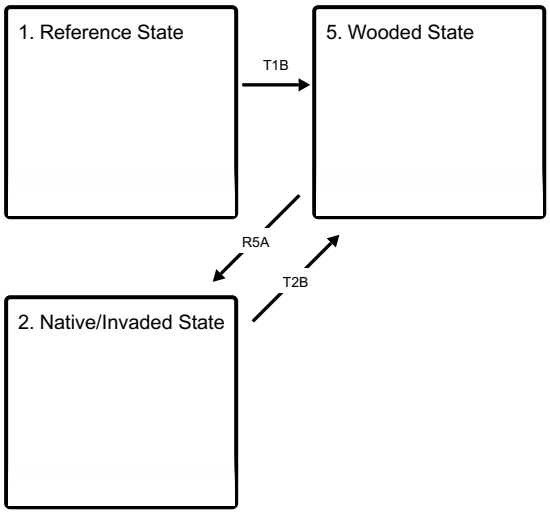
The plant community phase composition table(s) has been developed from the best available knowledge including research, historical records, clipping studies, and inventory records. As more data are collected, plant community species composition and production information may be revised.

State and transition model

Ecosystem states



States 1, 5 and 2 (additional transitions)



T1A - Introduction of exotic cool-season grasses

T1B - Extended period of non-use or very light grazing, no fire

T2B - Extended period of non-use or very light grazing, no fire

R3A - Long term prescribed grazing with prescribed burning

T3A - Extended period of non-use or very light grazing, no fire

R4A - Successful range planting with prescribed grazing and prescribed burning

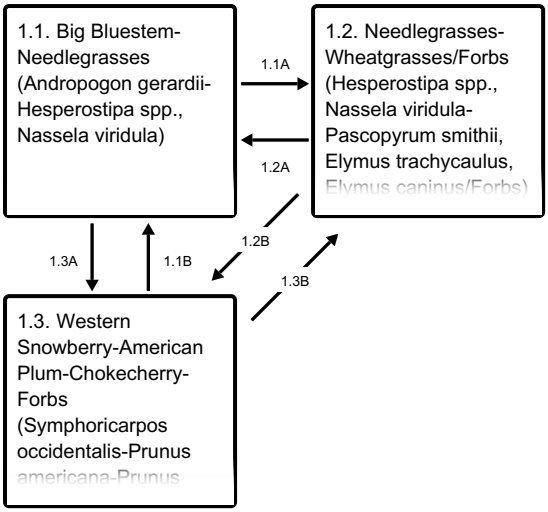
R4B - Failed range planting followed by secondary succession

R5A - Prescribed burning and/or chemical/mechanical brush management followed by successful range planting

R5B - Prescribed burning and/or chemical/mechanical brush management followed by failed range planting

T6A - Cessation of annual cropping

State 1 submodel, plant communities



1.1A - Below average precipitation, increased fire frequency, with or without heavy season-long grazing

1.3A - Return to average growing conditions and fire frequency with or without reduced grazing pressure

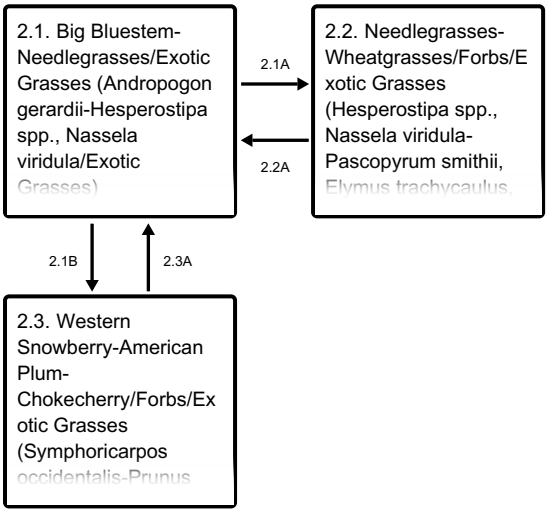
1.2A - Return to average growing conditions and fire frequency with or without reduced grazing pressure

1.2B - Above average precipitation and/or reduced grazing or fire frequency

1.1B - Above average precipitation and/or reduced grazing or fire frequency

1.3B - Below average precipitation, increased fire frequency, with or without heavy season-long grazing

State 2 submodel, plant communities



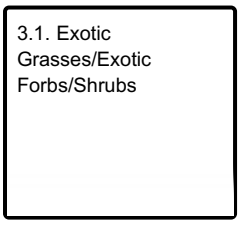
2.1A - Heavy season-long grazing with or without drought

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

2.2A - Reduced grazing pressure and return to average precipitation

2.3A - Long term prescribed grazing with prescribed burn

State 3 submodel, plant communities



State 4 submodel, plant communities

4.1. Annual/Pioneer Perennial/Exotics

State 5 submodel, plant communities

5.1. Hardwoods/Shrubs

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 state to shift both spatially and temporally between three community phases, two dominated by graminoids and a third dominated by shrubs and small trees.

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

- green ash (*Fraxinus pennsylvanica*), tree
- boxelder (*Acer negundo*), tree
- chokecherry (*Prunus virginiana*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- American plum (*Prunus americana*), shrub
- big bluestem (*Andropogon gerardii*), grass
- prairie cordgrass (*Spartina pectinata*), grass
- sideoats grama (*Bouteloua curtipendula*), grass
- porcupinegrass (*Hesperostipa spartea*), grass
- green needlegrass (*Nassella viridula*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- American licorice (*Glycyrrhiza lepidota*), other herbaceous
- Maximilian sunflower (*Helianthus maximiliani*), other herbaceous
- common yarrow (*Achillea millefolium*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- goldenrod (*Solidago*), other herbaceous

Community 1.1
Big Bluestem-Needlegrasses (Andropogon gerardii-Hesperostipa spp., Nassela viridula)

This community phase was historically the most dominant both temporally and spatially and consisted of a co-

dominant mixture of cool-season grasses and warm-season grasses. Major warm-season species included big bluestem, switchgrass, prairie cordgrass, Indiangrass, little bluestem, sideoats grama, and prairie dropseed. The predominant cool-season grasses were porcupinegrass, green needlegrass, needle and thread, western wheatgrass, bearded wheatgrass, and slender wheatgrass. Common forbs included American licorice, Maximillian sunflower, common yarrow, white heath aster, goldenrods, Canada anemone, and wavyleaf thistle. The more common shrubs included chokecherry and western snowberry. A small component of trees, such as green ash, boxelder, and others may also have been present. Annual production would have been around 3100-5100 pounds per acre. Graminoids constituted roughly 80% of the annual production, with forbs, shrubs, and trees contributing about 10%, 7%, and 3% of the production 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 (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2480	3280	4080
Forb	310	410	510
Shrub/Vine	217	287	357
Tree	93	123	153
Total	**3100**	**4100**	**5100**

Community 1.2
Needlegrasses-Wheatgrasses/Forbs (Hesperostipa spp., Nassela viridula-Pascopyrum smithii, Elymus trachycaulus, Elymus caninus/Forbs)

Community Phase 1.2 occurred when factors such as below average precipitation and increased fire frequency with or without heavy season-long grazing favored a community dominated by cool-season grasses such as the needlegrasses (e.g. porcupine, needle and thread, green needlegrass) and wheatgrasses (e.g. western, bearded, slender). Warm-season grasses included big bluestem, sideoats grama and prairie dropseed. Forbs increased in comparison to Community Phase 1.1 and often included common yarrow, white heath aster, and goldenrods. Compared to Community Phase 1.1, annual production would have been slightly lower. Due to the increase in cool-season grasses, peak production would have occurred earlier in the growing season.

Community 1.3
Western Snowberry-American Plum-Chokecherry-Forbs (Symphoricarpos occidentalis-Prunus americana-Prunus virginiana/Forbs)

Community Phase 1.3 occurred with above average precipitation and/or reduced grazing/fire frequency or other factors conducive to the establishment and expansion of woody vegetation. Common woody species in this community included western snowberry, American plum, chokecherry, leadplant, and wild rose, along with boxelder, green ash, and common hackberry. Although the community may appear to produce little forage, the bulk of forage production was grass, most of which was cool-season (i.e. wheatgrasses and needlegrasses). As such, the peak grass production occurred early in the growing season (i.e. spring and early summer).

Pathway 1.1A
Community 1.1 to 1.2

Community Phase Pathway 1.1 to 1.2 occurred during times of below average precipitation and increased fire frequency, with or without heavy season-long grazing. This resulted in a marked increase in wheatgrasses and forbs with a corresponding decrease in big bluestem. Graminoid composition shifted from a co-dominance of cool-season grasses (e.g. needlegrasses) and warm-season grasses (e.g. big bluestem) to a community dominated by cool-season grasses (e.g. needlegrasses, wheatgrasses). As a result, the peak production period shifted to earlier in the growing season.

Pathway 1.3A
Community 1.1 to 1.3

Community Phase Pathway 1.3 to 1.1 occurred upon a return to average growing conditions and fire frequency with or without reduced grazing pressure that was advantageous to warm-season grasses and suppresses woody species.

Pathway 1.2A
Community 1.2 to 1.1

Community Phase Pathway 1.2 to 1.1 occurred with the return to average growing conditions and fire frequency with or without reduced grazing pressure. This resulted in a marked increase in big bluestem and corresponding decrease in wheatgrasses and forbs.

Pathway 1.2B
Community 1.2 to 1.3

Community Phase Pathway 1.2 to 1.3 occurred during periods of above average precipitation and/or reduced grazing or fire frequency which enabled the woody vegetation (e.g. western snowberry, American plum, and chokecherry) to become dominant components of the community.

Pathway 1.1B
Community 1.3 to 1.1

Community Phase Pathway 1.1 to 1.3 occurred with above average precipitation and/or reduced grazing or fire frequency which was advantageous to the establishment and expansion of woody vegetation (e.g. western snowberry, chokecherry).

Pathway 1.3B
Community 1.3 to 1.2

Community Phase Pathway 1.3 to 1.2 occurred during below average precipitation and increased fire frequency, with or without reduced grazing pressure, which was advantageous to cool-season grasses.

State 2
Native/Invaded State

This state is similar to State 1: Reference State but has now been colonized by the exotic cool-season grasses, commonly Kentucky bluegrass, smooth brome, and/or quackgrass 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 3: 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. However, annual production may range from around 2200-4100 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

- green ash (*Fraxinus pennsylvanica*), tree
- western snowberry (*Symphoricarpos occidentalis*), shrub
- chokecherry (*Prunus virginiana*), shrub
- American plum (*Prunus americana*), shrub
- green needlegrass (*Nassella viridula*), grass
- needle and thread (*Hesperostipa comata*), grass
- porcupinegrass (*Hesperostipa spartea*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- slender wheatgrass (*Elymus trachycaulus*), grass
- smooth brome (*Bromus inermis*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- quackgrass (*Elymus repens*), grass
- common yarrow (*Achillea millefolium*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- Canada goldenrod (*Solidago altissima*), other herbaceous

Community 2.1
Big Bluestem-Needlegrasses/Exotic Grasses (Andropogon gerardii-Hesperostipa spp., Nassela viridula/Exotic Grasses)

This community phase is similar to Community Phase 1.1 with the additional presence of minor amounts of exotic cool-season rhizomatous grasses such as Kentucky bluegrass, smooth brome, and/or quackgrass. Annual production may be comparable to that of Community Phase 1.1 (3100-5100 pounds per acre). However, as the exotic cool-season grasses increase, peak production will shift to earlier in the growing season.

Community 2.2
Needlegrasses-Wheatgrasses/Forbs/Exotic Grasses (Hesperostipa spp., Nassela viridula-Pascopyrum smithii, Elymus trachycaulus, Elymus caninus/Forbs/Exotic Grasses)

This community occurs with heavy season-long grazing, with or without drought, which leads to a community largely composed of cool-season grasses. It is similar to Community Phase 1.2 with a marked increase in forbs and the addition of exotic cool-season grasses, often Kentucky bluegrass, smooth brome, and/or quackgrass. Forbs common to this community phase include common yarrow, white heath aster, and goldenrods. 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. 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.

Community 2.3
Western Snowberry-American Plum-Chokecherry/Forbs/Exotic Grasses (Symphoricarpos occidentalis-Prunus americana-Prunus virginiana/Forbs/Exotic Grasses)

This community phase forms during periods of above average precipitation and/or reduced grazing or fire frequency which is advantageous to the establishment and expansion of woody vegetation (e.g. western snowberry and chokecherry). It may be characterized by the dominance of shrubs such as western snowberry, chokecherry, hawthorn, and perhaps common buckthorn, alone or in combination. Green ash seedlings may also be present. Forb species are similar to that of other phases in this state; however, heavy shading from the shrubs may largely limit their distribution to the community margins. The graminoid component is dominated by exotic cool-season grasses Kentucky bluegrass, smooth brome, and/or quackgrass, with Sprengel's sedge and other sedges dominating the more heavily shaded areas. Extended periods of no use and no fire may lead to the transition to State 5: Wooded State.

Pathway 2.1A
Community 2.1 to 2.2

Community Phase Pathway 2.1 to 2.2 occurs with heavy season-long grazing with or without drought, resulting in a marked increase in the exotic cool-season grasses, wheatgrasses, and forbs with a corresponding decrease in big bluestem. As a result, peak production shifts to earlier in the growing season.

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 which is advantageous to the establishment and expansion of woody vegetation (e.g. western snowberry and chokecherry).

Pathway 2.2A
Community 2.2 to 2.1

Community Phase Pathway 2.2 to 2.1 occurs with reduced grazing pressure and return to average precipitation. These factors are advantageous to warm-season grasses leading to a marked increase in big bluestem and corresponding decrease in wheatgrasses and forbs. As the pathway progresses, peak grass production shifts to later in the growing season.

Pathway 2.3A
Community 2.3 to 2.1

Community Phase Pathway 2.3 to 2.1 occurs with long term prescribed grazing and prescribed burning, replacing the shrub dominated community to one dominated by native warm-season and cool-season grasses. Prescribed burning alone will generally require repeated treatments, in part because many of the shrubs (e.g. western snowberry) sprout profusely following burning.

State 3
Invaded State

This state is the result of invasion and dominance by the exotic cool-season grasses, commonly Kentucky bluegrass, smooth brome, and/or quackgrass. 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. Common forbs often include white heath aster, goldenrods, common yarrow, and white sagebrush. Shrubs such as western snowberry and prairie rose, however, may show marked increases. Noxious weeds such as Canada thistle and leafy spurge are also known to invade the site. 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 on this state may vary considerably, perhaps from around 1500 – 3100 lbs/acre. Collectively, the exotic cool-season grasses Kentucky bluegrass, smooth brome, and/or quackgrass can account for up to 75% or more of the total production. As a result, the bulk of the grass production (both quantity and quality) is restricted to a small period early in the growing season.

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
- Canada thistle (*Cirsium arvense*), other herbaceous
- leafy spurge (*Euphorbia esula*), other herbaceous
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- goldenrod (*Solidago*), other herbaceous

Community 3.1
Exotic Grasses/Exotic Forbs/Shrubs

This community phase is typically dominated by the exotic cool-season grasses Kentucky bluegrass, smooth brome, and/or quackgrass. There may also be a lesser amount of native cool-season and/or warm-season grasses present. However, a lack of further disturbance often results in dominance by smooth brome, while heavy season-long grazing often leads to a dominance of Kentucky bluegrass. Prescribed burning and prescribed grazing have been largely ineffective in reducing the importance of these exotic cool season grasses. Common exotic forbs include Canada thistle, leafy spurge, black medic, sweet clover, field sowthistle, and common dandelion. Native forbs are often a minor component of the community and may include white sagebrush, goldenrods, American licorice, and common yarrow. Shrubs such as western snowberry, chokecherry, and prairie rose may also be present.

State 4
Go-Back State

This state is highly variable depending on the level and duration of disturbance related to the T6A transitional pathway. In this MLRA, the most probable origin of this state is plant succession following cropland abandonment. This plant community will initially include a variety of annual forbs and grasses, some of which may be noxious weeds and need control. Over time, the exotic cool-season grasses Kentucky bluegrass, smooth brome, and/or quackgrass will likely predominate. However, If the site is adjacent to woodlands, sprouts and seeds from the woodland species may begin to encroach and colonize the site. Common forbs and shrubs often include northern bedstraw, goldenrods, common yarrow, Canada thistle, western snowberry, and wild rose.

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

- western snowberry (*Symphoricarpos occidentalis*), shrub
- prairie rose (*Rosa arkansana*), shrub

- cheatgrass (*Bromus tectorum*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- bristlegrass (*Setaria*), grass
- moist sowthistle (*Sonchus arvensis ssp. uliginosus*), other herbaceous
- Canada thistle (*Cirsium arvense*), other herbaceous
- bull thistle (*Cirsium vulgare*), other herbaceous
- curlycup gumweed (*Grindelia squarrosa*), other herbaceous
- northern bedstraw (*Galium boreale*), other herbaceous

Community 4.1
Annual/Pioneer Perennial/Exotics

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

State 5
Wooded State

This state historically existed as small patches of trees and/or shrubs scattered across the site, particularly when located near 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.

Dominant plant species

- green ash (*Fraxinus pennsylvanica*), tree
- American elm (*Ulmus americana*), tree
- American basswood (*Tilia americana*), tree
- American plum (*Prunus americana*), shrub
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- chokecherry (*Prunus virginiana*), shrub
- leadplant (*Amorpha canescens*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- white heath aster (*Symphyotrichum ericoides*), other herbaceous
- goldenrod (*Solidago*), other herbaceous
- Maximilian sunflower (*Helianthus maximiliani*), other herbaceous

Community 5.1
Hardwoods/Shrubs

In many situations this community phase is dominated by shrubs such as western snowberry, chokecherry, prairie rose, Saskatoon serviceberry, and leadplant. Kentucky bluegrass and/or smooth brome are generally the main grasses with a forb component which may include white heath aster, silverleaf Indian breadroot, goldenrods, and sunflowers. Older stands may include green ash, American elm, basswood, boxelder, American plum, small patches of quaking aspen clones, hazelnut, and/or perhaps hawthorn. Heavy shading, often in the center of some of these stands, often results in a depauperate understory consisting of sedges such as Sprengel’s sedge with few forbs.

State 6
Cropland State

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, and/or quackgrass. 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 this transition. The threshold between states was 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 T1B
State 1 to 5

This transition from State 1: Reference State to State 5: Wooded State occurred over extended periods of no use or very light grazing and no fire. Adjacent or nearby stands of woody species would have encroached onto the site vegetatively (e.g. rhizomes, root sprouts) or provided a seed source for colonization of the site. Common woody species often include western snowberry, chokecherry, American plum, wild rose, and green ash. Changes in fire frequency allowed woody plant species 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.

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

Transition T2A
State 2 to 3

This transition pathway from the State 2: Native/Invaded State to State 3: Invaded State occurs over extended periods of no use or very light grazing and no fire. Exotic cool-season grasses such as quackgrass, Kentucky bluegrass, and/or perhaps smooth brome become the dominant graminoids. This transition may also occur with heavy season-long grazing (primarily Kentucky bluegrass). A threshold may be crossed when Kentucky bluegrass exceeds 30% of the community composition and native grasses account for less than 40% composition. Similar thresholds may exist for smooth brome 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.

Context dependence. Extended period of non-use or very light grazing, no fire

Transition T2B
State 2 to 5

This transition from State 2: Native/Invaded State to State 5: Wooded State occurs over extended periods of no use or very light grazing and no fire, enabling adjacent or nearby stands of woody species to encroach onto the site vegetatively (e.g. rhizomes, root sprouts) or by providing a seed source for colonization of the site. Common woody species may include western snowberry, chokecherry, American plum, prairie rose, and green ash.

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

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

Restoration pathway 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).

Transition T3A
State 3 to 5

This transition from State 3: Invaded State to State 5: Wooded State occurs during extended periods of no use or very light grazing and no fire. Adjacent or nearby stands of woody species can encroach onto the site vegetatively (e.g. rhizomes, root sprouts) or provide a seed source for colonization of the site. Common woody species include western snowberry, chokecherry, American plum, prairie rose, and green ash.

Constraints to recovery. Labor and financial cost of removal/control of woody species either through repeated

prescribed burns, mechanical and/or chemical treatment.

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

Restoration pathway R4A
State 4 to 2

Restoration pathway from State 4: Go-Back State to 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. 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, 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.

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.

Restoration pathway R5A
State 5 to 2

This restoration pathway from State 5: Wooded State to State 2: Native/Invaded State can occur with prescribed burning and/or chemical/mechanical brush management followed by a successful range planting. A combination of mechanical brush management, chemical treatment, and prescribed burning is necessary to remove the woody vegetation and 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 and other restoration practices such as range planting or prescribed burning, 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.

Restoration pathway R5B
State 5 to 3

This restoration pathway from State 5: Wooded State to State 3: Invaded State can occur with prescribed burning and/or chemical/mechanical brush management followed by a failed range planting.

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

Transition T6A
State 6 to 4

This is the Transition from any plant community to State 4: Go-Back State. It is most commonly associated with the cessation of cropping without the benefit of range planting, resulting in a “go-back” situation. Soil conditions can be quite variable on the site, in part due to variations in the management/cropping history (e.g. development of tillage induced compaction layer, 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**			820–1230	
	big bluestem	ANGE	*Andropogon gerardii*	820–1230	–
	switchgrass	PAVI2	*Panicum virgatum*	41–410	–
	prairie cordgrass	SPPE	*Spartina pectinata*	41–410	–
	Indiangrass	SONU2	*Sorghastrum nutans*	41–410	–
2	**Needlegrasses**			410–820	
	porcupinegrass	HESP11	*Hesperostipa spartea*	82–615	–

	porcupinegrass	HESP11	*Hesperostipa spartea*	82–410	–
	needle and thread	HECO26	*Hesperostipa comata*	41–410	–
	green needlegrass	NAVI4	*Nassella viridula*	41–410	–
3	**Mid Cool-Season Grasses**			82–165	
	western wheatgrass	PASM	*Pascopyrum smithii*	82–410	–
	bearded wheatgrass	ELCA11	*Elymus caninus*	82–410	–
	slender wheatgrass	ELTR7	*Elymus trachycaulus*	82–410	–
	northern reedgrass	CASTI3	*Calamagrostis stricta ssp. inexpansa*	0–205	–
	Canada wildrye	ELCA4	*Elymus canadensis*	41–205	–
4	**Warm-Season Grasses**			0–205	
	little bluestem	SCSC	*Schizachyrium scoparium*	0–205	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	0–205	–
	prairie dropseed	SPHE	*Sporobolus heterolepis*	0–205	–
5	**Other Native Grasses**			0–205	
	Leiberg's panicum	DILE2	*Dichanthelium leibergii*	0–205	–
	mat muhly	MURI	*Muhlenbergia richardsonis*	0–205	–
	Grass, perennial	2GP	*Grass, perennial*	0–205	–
6	**Grass-likes**			0–205	
	Pennsylvania sedge	CAPE6	*Carex pensylvanica*	41–205	–
	Grass-like (not a true grass)	2GL	*Grass-like (not a true grass)*	0–205	–
Forb					
7	**Forbs**			205–410	
	Forb (herbaceous, not grass nor grass-like)	2FORB	*Forb (herbaceous, not grass nor grass-like)*	41–205	–
	American licorice	GLLE3	*Glycyrrhiza lepidota*	41–123	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	41–123	–
	common yarrow	ACMI2	*Achillea millefolium*	41–82	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	41–82	–
	Canadian anemone	ANCA8	*Anemone canadensis*	0–82	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	41–82	–
	wavyleaf thistle	CIUN	*Cirsium undulatum*	41–82	–
	purple prairie clover	DAPU5	*Dalea purpurea*	41–82	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	41–82	–
	stiff goldenrod	OLRI	*Oligoneuron rigidum*	41–82	–
	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	41–82	–
	cinquefoil	POTEN	*Potentilla*	41–82	–
	upright prairie coneflower	RACO3	*Ratibida columnifera*	41–82	–
	ragwort	SENEC	*Senecio*	41–82	–
	Canada goldenrod	SOCA6	*Solidago canadensis*	41–82	–
	white heath aster	SYER	*Symphyotrichum ericoides*	41–82	–
	American vetch	VIAM	*Vicia americana*	41–82	–
	golden tickseed	COTI3	*Coreopsis tinctoria*	0–41	–
	wood lily	LIPH	*Lilium philadelphicum*	0–41	–
	soft-hair marbleseed	ONBEB	*Onosmodium bejariense var.*	0–41	–

			bejariense		
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	0–41	–
Shrub/Vine					
8	**Shrubs**			0–287	
	western snowberry	SYOC	*Symphoricarpos occidentalis*	41–205	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–205	–
	American plum	PRAM	*Prunus americana*	41–123	–
	chokecherry	PRVI	*Prunus virginiana*	0–123	–
	leadplant	AMCA6	*Amorpha canescens*	41–82	–
	prairie rose	ROAR3	*Rosa arkansana*	41–82	–
	hawthorn	CRATA	*Crataegus*	0–41	–
Tree					
9	**Trees**			0–123	
	boxelder	ACNE2	*Acer negundo*	0–123	–
	common hackberry	CEOC	*Celtis occidentalis*	0–123	–
	green ash	FRPE	*Fraxinus pennsylvanica*	0–123	–
	hophornbeam	OSVI	*Ostrya virginiana*	0–123	–
	eastern cottonwood	PODE3	*Populus deltoides*	0–123	–
	willow	SALIX	*Salix*	0–123	–
	American basswood	TIAM	*Tilia americana*	0–123	–
	American elm	ULAM	*Ulmus americana*	0–123	–
	Tree	2TREE	*Tree*	0–123	–

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	09/27/2024
Approved by	Suzanne Mayne-Kinney
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

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

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

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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):**

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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:**
