Natural Resources
Conservation Service

# Ecological site FX053A99X701
# Clay (Cl)

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Accessed: 05/12/2025

## 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): 053A–Northern Dark Brown Glaciated Plains

The Northern Dark Brown Glaciated Plains, MLRA 53A, is a large, agriculturally and ecologically significant area. It consists of approximately 6.1 million acres and stretches 140 miles from east to west and 120 miles from north to south, encompassing portions of 8 counties in northeastern Montana and northwestern North Dakota. This region represents part of the southern edge of the Laurentide Ice Sheet during maximum glaciation. It is one of the driest and westernmost areas within the vast network of glacially derived prairie pothole landforms of the Northern Great Plains and falls roughly between the Missouri Coteau to the east and the Brown Glaciated Plains to the west. Elevation ranges from 1,800 feet (550 meters) to 3,300 feet (1,005 meters).

Soils are primarily Mollisols, but Inceptisols and Entisols are also common. Till from continental glaciation is the predominant parent material, but alluvium and bedrock are also common. Till deposits are typically less than 50 feet thick (Soller, 2001). Underlying the till is sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007). The bedrock is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur in glacial outwash channels and along major drainages, including portions of the Missouri, Poplar, and Big Muddy Rivers. Large eolian deposits of sand occur in the vicinity of the ancestral Missouri River channel east of Medicine Lake (Fullerton et al., 2004). The northwestern portion of the MLRA contains a large unglaciated area containing paleoterraces and large deposits of sand and gravel known as the Flaxville gravel.

Much of this MLRA was glaciated towards the end of the Wisconsin age, and the maximum glacial extent occurred approximately 20,000 years ago (Fullerton and Colton, 1986; Fullerton et al., 2004). Subsequent erosion from major stream and river systems has created numerous drainageways throughout much of the MLRA. The result is a geologically young landscape that is predominantly a dissected till plain interspersed with alluvial deposits and dominated by soils in the Mollisol and Inceptisol orders. Much of this area is typic ustic, making these soils very productive and generally well suited to production agriculture.

Dryland farming is the predominant land use, and approximately 50 percent of the land area is used for cultivated crops. Winter, spring, and durum varieties of wheat are the major crops, with over 48 million bushels produced annually (USDA-NASS, 2017). Areas of rangeland typically are on steep hillslopes along drainages. The rangeland is mostly native mixedgrass prairie similar to the Stipa-Agropyron, Stipa-Bouteloua-Agropyron, and Stipa-Bouteloua faciations (Coupland, 1950, 1961). Cool-season grasses dominate and include rhizomatous wheatgrasses, needle and thread, western porcupine grass, and green needlegrass. Woody species are generally rare; however, many of the steeper drainages support stands of trees and shrubs such as green ash and chokecherry. Seasonally ponded, prairie pothole wetlands may occur throughout the MLRA, but the greatest concentrations are in the east and northeast where receding glaciers stagnated and formed disintegration moraines with hummocky topography and numerous areas of poorly drained soils.

## Classification relationships

National Hierarchical Framework of Ecological Units (Cleland et al., 1997; McNab et al., 2007)
• Domain: Dry
• Division: Temperate Steppe
• Province: Great Plains-Palouse Dry Steppe Province 331
• Section: Glaciated Northern Grasslands Section 331L
• Subsection: Glaciated Northern Grasslands Subsection 331La
• Landtype association/Landtype phase: N/A

National Vegetation Classification Standard (Federal Geographic Data Committee, 2008)
• Class: Mesomorphic Shrub and Herb Vegetation Class (2)
• Subclass: Temperate and Boreal Grassland and Shrubland Subclass (2.B)
• Formation: Temperate Grassland and Shrubland Formation (2.B.2)
• Division: Central North American Grassland and Shrubland Division (2.B.2.Nb)
• Macrogroup: Hesperostipa comata - *Pascopyrum smithii* - Festuca hallii Grassland Macrogroup (2.B.2.Nb.2)
• Group: *Pascopyrum smithii* - Hesperostipa comata - Schizachyrium scoparium Mixedgrass Prairie Group (2.B.2.Nb.2.c)

EPA Ecoregions
• Level 1: Great Plains (9)
• Level 2: West-Central Semi-Arid Prairies (9.3)
• Level 3: Northwestern Glaciated Plains (42)
• Level 4: Glaciated Dark Brown Prairie (42i)
Glaciated Northern Grasslands (42j)

## Ecological site concept

Clay is an ecological site of limited extent occurring on stream terraces and outwash fans. The distinguishing characteristic of this site is that it contains greater than 35 percent clay in the upper 4 inches of soil. Soils for this ecological site are typically moderately deep to very deep (more than 20 inches to bedrock), well drained, and derived from clayey alluvium or glaciofluvial deposits. Characteristic vegetation is western wheatgrass (*Pascopyrum smithii*), prairie Junegrass (*Koeleria macrantha*), and green needlegrass (*Nassella viridula*).

## Associated sites

| | |
|---|---|
| FX053A99X032 | **Loamy (Lo)**<br>Loamy is on similar landscapes and slope positions as Clay but where clay content is 35 percent or less. |
| FX053A99X131 | **Shallow Clay (SwC)**<br>Shallow Clay is found adjacent to Clay where bedrock occurs near the soil surface. It typically occupies a backslope position downslope from the Clay ecological site. |

## Similar sites

| | |
|---|---|
| FX053A99X131 | **Shallow Clay (SwC)**<br>This site differs from Clay in that depth to bedrock or paralithic bedrock is less than 20 inches. |
| FX053A99X032 | **Loamy (Lo)**<br>This site differs from Clay in that its soils contain 35 percent or less clay in the surface 4 inches whereas in the Clay ecological site, the soil contains more than 35 percent clay in the surface 4”. |

**Table 1. Dominant plant species**

| | |
|---|---|
| Tree | Not specified |
| Shrub | Not specified |
| Herbaceous | (1) *Pascopyrum smithii*<br>(2) *Nassella viridula* |

## Legacy ID

## Physiographic features

The Clay ecological site occurs on a variety of landforms across MLRA 53A. It occurs on till plains, moraines, hillslopes, fans, and stream terraces where slopes are less than 15 percent. Typical hillslope positions are backslopes, footslopes, shoulders, or summits. The slope shape is typically linear or concave.

**Table 2. Representative physiographic features**

| | |
|---|---|
| Hillslope profile | (1) Backslope<br>(2) Footslope<br>(3) Shoulder<br>(4) Summit |
| Landforms | (1) Till plain > Moraine<br>(2) Till plain > Hillslope<br>(3) Till plain > Fan<br>(4) River valley > Stream terrace |
| Flooding frequency | None |
| Ponding frequency | None |
| Elevation | 549–1,006 m |
| Slope | 0–14% |
| Aspect | Aspect is not a significant factor |

## Climatic features

The Northern Dark Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Coupland, 1958; Richardson and Hanson, 1977; Heidel et al., 2000). The majority of precipitation occurs as steady, soaking, frontal system rains in late spring to early summer. Summer rainfall comes mainly from convection thunderstorms that typically deliver scattered amounts of rain in intense bursts. These storms may be accompanied by damaging winds and large-diameter hail and result in flash flooding along low-order streams. Approximately 80 percent of the annual precipitation occurs during the growing season. June is the wettest month, followed by July and May (Richardson and Hanson, 1977; Heidel et al., 2000). Average annual precipitation ranges from 11 inches (280 mm) near Richey, Montana, to 15 inches (380 mm) in the Little Muddy drainage near Williston, North Dakota, but precipitation varies greatly from year to year. On average, severe drought and very wet years occur with the same frequency, which is 1 out of 10 years (Coupland, 1958; Heidel et al., 2000). Extreme climatic variations, especially droughts, have the greatest influence on species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). The frost-free period for this ecological site ranges from 90 to 130 days, and the freeze-free period ranges from 115 to 155 days.

**Table 3. Representative climatic features**

| | |
|---|---|
| Frost-free period (characteristic range) | 90-130 days |
| Freeze-free period (characteristic range) | 115-155 days |
| Precipitation total (characteristic range) | 279-381 mm |
| Frost-free period (average) | 110 days |
| Freeze-free period (average) | 135 days |
| Precipitation total (average) | 330 mm |

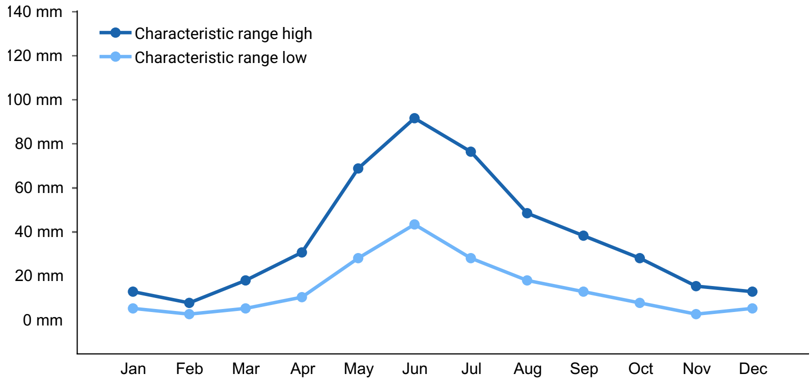



**Figure 1. Monthly precipitation range**

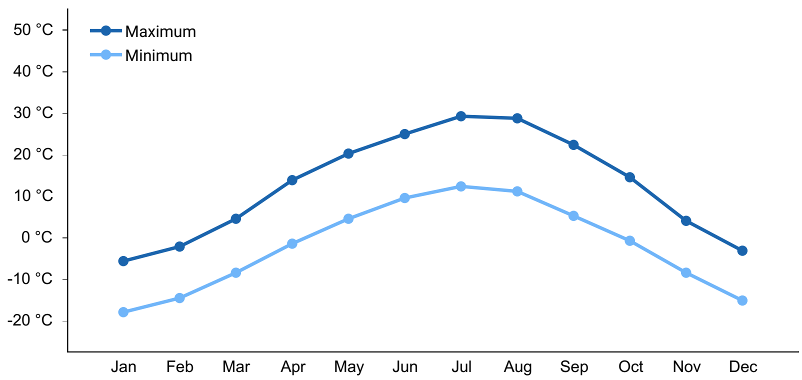



**Figure 2. Monthly average minimum and maximum temperature**

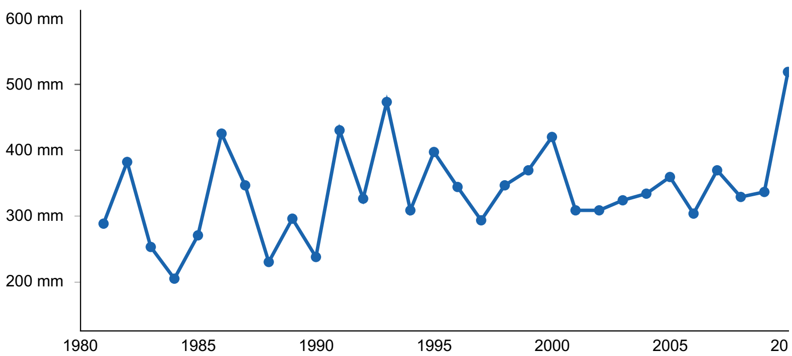



**Figure 3. Annual precipitation pattern**

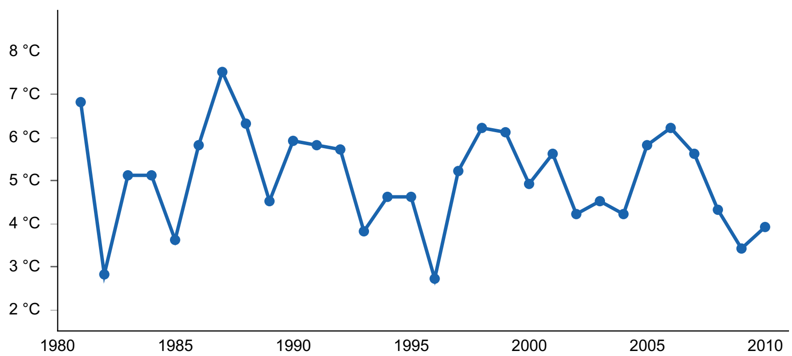



**Figure 4. Annual average temperature pattern**

## Climate stations used

- (1) BREDETTE [USC00241088], Poplar, MT
- (2) CULBERTSON [USC00242122], Culbertson, MT
- (3) OPHEIM 10 N [USC00246236], Opheim, MT

- (4) OPHEIM 12 SSE [USC00246238], Opheim, MT
- (5) PLENTYWOOD [USC00246586], Plentywood, MT
- (6) SCOBEY 4 NW [USC00247425], Scobey, MT
- (7) SIDNEY [USC00247560], Sidney, MT
- (8) VIDA 6 NE [USC00248569], Vida, MT
- (9) WILLISTON SLOULIN INTL AP [USW00094014], Williston, ND

## Influencing water features

This is an upland ecological site and is not influenced by a water table or run-in from adjacent sites. Due to the semi-arid climate in which it occurs, the water budget is normally contained within the soil pedon. Soil moisture is recharged by spring rains, but it rarely exceeds field capacity in the upper 40 inches before being depleted by evapotranspiration. During intense precipitation events, precipitation rates frequently exceed infiltration rates and this site delivers moisture to downslope sites via surface runoff. Moisture loss through evapotranspiration exceeds precipitation for the majority of the growing season, and soil moisture is the primary limiting factor for plant production on this ecological site.

## Soil features

Soils for this ecological site are typically moderately deep to very deep (more than 20 inches to bedrock), well drained, and derived from clayey alluvium or glaciofluvial deposits. They have a typic ustic moisture regime, which means that the soils are moist in some or all parts for either 180 cumulative days or 90 consecutive days during the growing season but are dry in some or all parts for over 90 cumulative days, and a frigid soil temperature regime (Soil Survey Staff, 2014).

Surface horizon textures are typically clay, silty clay, clay loam, or silty clay loam and contain greater than 35 percent clay. The underlying horizons typically contain 35 to 60 percent clay and have clay, clay loam, or silty clay loam textures. Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. In the surface upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH classes are moderately acid to slightly alkaline in the surface horizon and neutral to strongly alkaline in the subsurface horizons. Content of coarse fragments is less than 35 percent in the upper 20 inches of soil.

**Table 4. Representative soil features**

| | |
|---|---|
| Parent material | (1) Till–igneous, metamorphic and sedimentary rock<br>(2) Alluvium–igneous, metamorphic and sedimentary rock |
| Surface texture | (1) Clay<br>(2) Silty clay<br>(3) Clay loam<br>(4) Silty clay loam |
| Drainage class | Well drained |
| Soil depth | 51–183 cm |
| Electrical conductivity (0-50.8cm) | 0–3 mmhos/cm |
| Sodium adsorption ratio (0-50.8cm) | 0–12 |
| Subsurface fragment volume <=3" (0-50.8cm) | 0–34% |
| Subsurface fragment volume >3" (0-50.8cm) | 0–34% |

## Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM), was developed based on historical data, current field data, professional experience, and a review of the scientific literature. As a result, all possible scenarios or plant species may not be included. Key indicator plant species, disturbances, and ecological processes are described to inform land management decisions.

The Clay provisional ecological site in MLRA 53A consists of six states: the Historic Reference State (1), the Contemporary Reference State (2), the Shortgrass State (3), the Invaded State (4), the Cropland State (5), and the Post-Cropland State (6). Plant communities associated with this ecological site evolved under the combined influences of climate, grazing, and fire. Extreme climatic variability results in frequent droughts, which have the greatest influence on the relative contribution of species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). Due to the dominance of cool-season graminoids, annual production is highly dependent upon mid- to late-spring precipitation (Heitschmidt and Vermeire, 2005; Anderson, 2006).

The historic ecosystem experienced periodic lightning-caused fires with estimated fire return intervals of 6 to 25 years (Bragg, 1995). Historically, Native Americans also set periodic fires. The majority of lightning-caused fires occurred in July and August, whereas Native Americans typically set fires during spring and fall to correspond with the movement of bison (Higgins, 1986). The precise effects of the historic fire return interval are not definitive, but in general the mixedgrass ecosystem was resilient to fire. Potential effects are generally temporary and may include reduction of litter, fluctuations in production, and changes in species composition (Vermeire et al., 2011, 2014).

Native grazers also shaped these plant communities. American bison (Bison bison) were the dominant historic grazer, but pronghorn (Antilocapra americana), elk (Cervus canadensis), and deer (Odocoileus spp.) were also common. Additionally, small mammals such as prairie dogs (Cynomys spp.) and ground squirrels (Urocitellus spp.) influenced this plant community (Salo et al., 2004). Grasshoppers and periodic outbreaks of Rocky Mountain locusts (Melanoplus spretus) also played an important role in the ecology of these communities (Lockwood, 2004). The mixedgrass ecosystem was resilient to grazing, although localized areas could experience shifts in species composition due to heavy grazing.

Following European settlement, fire was largely eliminated, domestic livestock replaced native ungulates as the primary grazers, and non-native species were introduced to the ecosystem. Aside from drought, livestock grazing is now the principle disturbance on the landscape.

Improper grazing of this site can result in a reduction in the cover of the mid-statured grasses and an increase in shortgrasses such as prairie Junegrass. Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year and/or that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and/or inadequate seasonal rotation moves over multiple years. Periods of extended drought (approximately 3 years or more) can reduce mid-statured, cool-season grasses and shift the species composition of this community to one dominated by blue grama (Coupland, 1958, 1961). Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses, in particular prairie Junegrass.

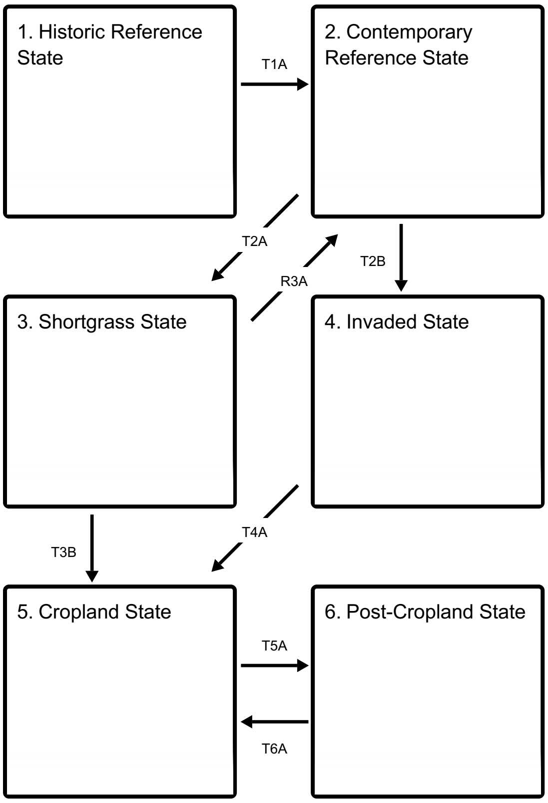
The effects of an altered fire regime are not completely understood at the time of this writing, but evidence suggests that long-term fire suppression can result in accumulations of litter and may contribute to increased abundance of non-native grasses (Murphy and Grant, 2005; Vermeire et al., 2011; Whisenant, 1990). Conversely, fire return intervals of less than 6 years, such as annual burning, can reduce productivity and shift species composition toward warm-season, short-statured grasses (Shay et al., 2001; Smith and McDermid, 2014).

Some of the Clay ecological site has been converted to annual cropland. The most common crops are cereal grain crops, such as winter wheat, spring wheat, and barley. When taken out of production, this site is either allowed to revert back to perennial grassland or is seeded back to perennial grass. Such seedings may be comprised of introduced grasses and legumes or a mix of native species. Sites left to undergo natural plant succession after cultivation can, over several decades, support native vegetation similar to the Reference State (1) (Christian and Wilson, 1999) although it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar et al., 1990). Sites seeded with non-native species may persist with this cover type indefinitely (Christian and Wilson, 1999). A mix of native species may also be seeded, however, a return to the Reference State (1) in a reasonable amount of time is unlikely.

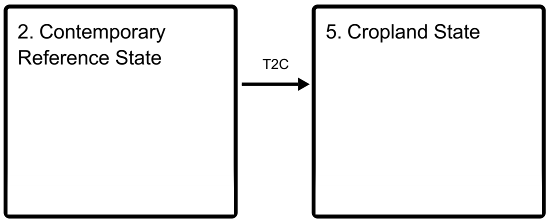
The state-and-transition model (STM) suggests possible pathways that plant communities on this site may follow as a result of a given set of ecological processes and management. The site may also support states not displayed in the STM diagram. Landowners and land managers should seek guidance from local professionals before prescribing a particular management or treatment scenario. Plant community responses vary across this MLRA due to variability in weather, soils, and aspect. The reference community phase may not necessarily be the management goal. The lists of plant species and species composition values are provisional and are not intended to cover the full range of conditions, species, and responses for the site. Species composition by dry weight is provided when available and is considered provisional based on the sources identified in the narratives associated with each community phase.

## State and transition model

**Ecosystem states**




**States 2 and 5 (additional transitions)**




**T1A** - Introduction of non-native grass species, such as Kentucky bluegrass, smooth brome, and crested wheatgrass.

**T2A** - Prolonged drought, improper grazing management, or a combination of these factors

**T2B** - Displacement of native species by non-native invasive species (Crested Wheatgrass, Kentucky bluegrass, noxious weeds, etc.)

**T2C** - Conversion to cropland

**R3A** - Range seeding, grazing land mechanical treatment, timely moisture, proper grazing management (management intensive and costly)

**T3B** - Conversion to cropland

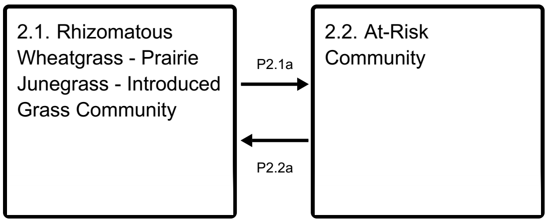
**T4A** - Conversion to cropland

**T5A** - Cessation of annual cropping

**T6A** - Conversion to cropland

**State 1 submodel, plant communities**

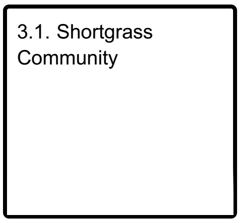
**State 2 submodel, plant communities**



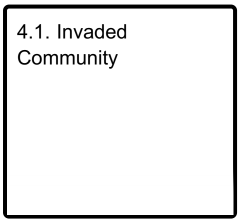

**P2.1a** - Drought, improper grazing management

**P2.2a** - Return to normal or above average precipitation, proper grazing management

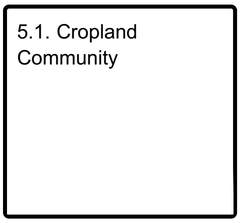
**State 3 submodel, plant communities**



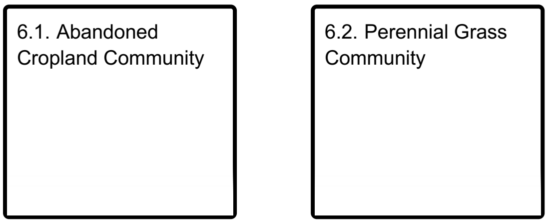

**State 4 submodel, plant communities**




**State 5 submodel, plant communities**




**State 6 submodel, plant communities**




## State 1
## Historic Reference State

The Historic Reference State (1) contains one community phase characterized by mid-statured rhizomatous wheatgrasses and prairie Junegrass (*Koeleria macrantha*). This state is considered extinct and is included here for historical reference purposes. It evolved under the combined influences of climate, grazing, and fire, with climatic variation having the greatest influence on cover and production. In general, this state was resilient to grazing; however, localized areas likely received heavy grazing, which resulted in the species composition shifting to short-statured species. Fire most likely resulted in a short-term shift from bunchgrasses to rhizomatous wheatgrass and warm-season grasses.

## Community 1.1

### Rhizomatous Wheatgrass - Prairie Junegrass Community

The Rhizomatous wheatgrass - Prairie Junegrass Phase (1.1) was characterized by mid-statured rhizomatous wheatgrasses and prairie Junegrass. Rhizomatous wheatgrasses were dominantly thickspike wheatgrass (*Elymus lanceolatus*) in the north and gradually transitioned to western wheatgrass ( *Pascopyrum smithii*) in the south as conditions became warmer and drier. The cool-season, perennial bunchgrass green needlegrass (*Nassella viridula*), was common, although not abundant (Coupland, 1950, 1961; Heidel et al., 2000). Prairie Junegrass was the dominant shortgrass. Forbs comprised about 10 percent of the cover and shrubs about 1 to 5 percent.

### State 2
### Contemporary Reference State

The Contemporary Reference State (2) contains two community phases characterized by mid-statured rhizomatous wheatgrasses and prairie Junegrass. It evolved under the combined influences of climate, grazing, and fire, with climatic variation having the greatest influence on cover and production. This state differs from the Historic Reference State in that it is influenced by introduced plant species and has altered fire and grazing regimes. In general, this state is resilient to grazing and fire, although these factors can influence species composition in localized areas.

### Community 2.1
### Rhizomatous Wheatgrass - Prairie Junegrass - Introduced Grass Community

The Rhizomatous wheatgrass - Prairie Junegrass - Introduced Grass Phase (2.1) is characterized by mid-statured rhizomatous wheatgrasses and prairie Junegrass. Rhizomatous wheatgrasses are dominantly thickspike wheatgrass in the north and gradually transition to western wheatgrass in the south as conditions became warmer and drier. The cool-season, perennial bunchgrass green needlegrass (*Nassella viridula*), is common, but not abundant (Coupland, 1950, 1961; Heidel et al., 2000). The dominant shortgrass is prairie Junegrass. Forbs comprise about 10 percent of the cover. Shrubs and subshrubs make up about 1 to 5 percent of the cover and include prairie sagewort (*Artemisia frigida*) and silver sagebrush (*Artemisia cana*). Non-native species comprise 1 to 3 percent of the plant community and may include brome grasses, Kentucky bluegrass (*Poa pratensis*) and crested wheatgrass (*Agropyron cristatum*).

### Community 2.2
### At-Risk Community

The At-Risk Community Phase (2.2) occurs when site conditions decline due to drought or improper grazing management. It is characterized by nearly equal proportions of shortgrasses and rhizomatous wheatgrasses. Mid-statured rhizomatous wheatgrasses are in decline and have been substantially reduced in both cover and vigor. Mid-statured bunchgrasses such as green needlegrass are rare or absent. Shortgrasses such prairie Junegrass are increasing. Prairie sagewort may also increase in this phase.

### Pathway P2.1a
### Community 2.1 to 2.2

Drought, improper grazing management, or a combination of these factors can shift the Rhizomatous wheatgrass - Prairie Junegrass - Introduced Grass Phase (2.1) to the At-Risk Community Phase (2.2). These factors favor an increase in shortgrasses such as prairie Junegrass and a decrease in midgrasses (Coupland, 1961).

### Pathway P2.2a
### Community 2.2 to 2.1

Normal or above-normal spring precipitation and proper grazing management transition the At-Risk Community (2.2) back to the Mixedgrass – Introduced Grass Community (2.1).

### State 3
### Shortgrass State

The Shortgrass State (3) consists of one community phase. The dynamics of this state are driven by long-term drought, improper grazing management, or a combination of these factors. Shortgrasses increase with long-term improper grazing at the expense of cool-season midgrasses (Coupland, 1961; Biondini and Manske, 1996). In particular, communities dominated by blue grama can alter soil properties, creating conditions that resist establishment of other grass species (Dormaar and Willms, 1990; Dormaar et al., 1994). Reductions in stocking rates can reduce shortgrass cover and increase the cover of cool-season midgrasses, although this recovery may take decades (Dormaar and Willms, 1990; Dormaar et al., 1994).

### Community 3.1
### Shortgrass Community

The Shortgrass Community Phase (3.1) occurs when site conditions decline due to long-term drought or improper grazing. Mid-statured grasses such as rhizomatous wheatgrasses and green needlegrass have been largely eliminated. Short-statured species such as prairie Junegrass and blue grama dominate the plant community. The subshrub prairie sagewort is common.

### State 4
### Invaded State

The Invaded State (4) occurs when invasive plant species invade adjacent native grassland communities and displace the native species. Data suggest that native species diversity declines significantly when invasive species exceed 30 percent of the plant community. Non-native perennial grasses, such as crested wheatgrass and Kentucky bluegrass are the most widespread concerns. Crested wheatgrass has been planted on an estimated 20 million acres in the western U.S. since the 1930s (Holechek, 1981). It is extremely drought tolerant, establishes readily on a variety of soil types, has high seedling vigor, and can dominate the seedbank of invaded grasslands (Rogler and Lorenz, 1983; Henderson and Naeth, 2005). Kentucky bluegrass is widespread throughout the Northern Great Plains (Toledo et al., 2014) and mainly affects the moister portions of this site. It is very competitive and displaces native species by forming dense root mats, altering nitrogen cycling, and having allelopathic effects on germination (DeKeyser et al., 2013). It may also alter soil surface hydrology and modify soil surface structure (Toledo et al., 2014). Plant communities dominated by Kentucky bluegrass have significantly less cover of native grass and forb species (Toledo et al., 2014; DeKeyser et al., 2009). Smooth brome is less widespread, but it may also become a concern in some areas. Invasive grass species can invade relatively undisturbed grasslands, and it is not clear what triggers them to displace native species. In some cases, they have been found to substantially increase under long-term grazing exclusion (DeKeyser et al., 2009, 2013; Grant et al., 2009), but a consistent correlation to grazing management practices cannot be made at this time. Noxious weeds such as leafy spurge and Canada thistle are not widespread in MLRA 53A, but they can be a concern in localized areas. These species are very aggressive perennials. They typically displace native species and dominate ecological function when they invade a site. In some cases, these species can be suppressed through intensive management (herbicide application, biological control, or intensive grazing management). Control efforts are unlikely to eliminate noxious weeds, but their density can be sufficiently suppressed so that species composition and structural complexity are similar to that of the Contemporary Reference State (2). However, cessation of control methods will most likely result in recolonization of the site by the noxious species.

### Community 4.1
### Invaded Community

Encroachment by introduced grasses, noxious weeds, and other invasive species is common. Reduced plant species diversity, simplified structural complexity, and altered biologic processes result in a state that is substantially departed from both the Reference State (1) and the Contemporary Reference State (2).

### State 5
### Cropland State

The Cropland State (5) occurs when land is put into cultivation. Major crops in MLRA 53A are small grains such as wheat.

### Community 5.1
### Cropland Community

Annual, cool-season cereal grains, such as spring wheat, winter wheat, and barley, are the most common crops.

## State 6
## Post-Cropland State

The Post-Cropland State (6) occurs when cultivated cropland is abandoned and allowed to either revegetate naturally or is seeded back to perennial species for grazing or wildlife use. This state can transition back to the Cropland State (5) if the site is put back into cultivation.

## Community 6.1
## Abandoned Cropland Community

The Abandoned Cropland Community Phase (6.1) typically occurs when cropland is abandoned with no further management. It may also occur when cropland is abandoned and then seeded to perennial forage species and the reseeding fails. In the absence of active management, the site can revegetate naturally and, over time, potentially return to a perennial grassland community with bunchgrasses and blue grama. Shortly after cropland is abandoned, annual and biennial forbs and annual brome grasses invade the site (Samuel and Hart, 1994). The site is extremely susceptible to erosion due to the absence of perennial species. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses. Depending on the historical management of the site, perennial bunchgrasses may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species, such as crested wheatgrass or Kentucky bluegrass, will depend upon the site's proximity to a seed source. Fifty or more years after cultivation, these sites may have species composition similar to phases in the Contemporary Reference State (2). However, soil quality is consistently lower than under conditions prior to cultivation (Dormaar and Smoliak, 1985; Christian and Wilson, 1999) and a shift to the Contemporary Reference State (2) is unlikely within a reasonable time frame.

## Community 6.2
## Perennial Grass Community

The Perennial Grass Community Phase (6.2) occurs when the site is seeded to perennial species for livestock forage or wildlife cover. Seedings typically are comprised of introduced species such as intermediate wheatgrass (*Thinopyrum intermedium*) and alfalfa (*Medicago sativa*), which can persist for several decades. Aggressive species such as crested wheatgrass and smooth brome can form monocultures persisting for at least 60 years (Krzic et al., 2000; Henderson and Naeth, 2005) and can invade adjacent sites if conditions are favorable. A mixture of native species may also be seeded to provide species composition and structural complexity similar to those of the Contemporary Reference State (2). However, soil quality conditions have been substantially altered and will not return to pre-cultivation conditions within a reasonable timeframe (Dormaar et al., 1990).

## Transition T1A
## State 1 to 2

Introduction of non-native grass species occurred in the early 20th century. The naturalization of these species in relatively undisturbed grasslands, coupled with changes in fire and grazing regimes, transitions the Reference State (1) to the Contemporary Reference State (2).

## Transition T2A
## State 2 to 3

Prolonged drought, improper grazing practices, or a combination of these factors weaken the resilience of the Contemporary Reference State (2) and drive its transition to the Shortgrass State (3). The Contemporary Reference State (2) transitions to the Shortgrass State (3) when mid-statured grasses become rare and contribute little to production. Shortgrasses such as prairie Junegrass and blue grama (*Bouteloua gracilis*) dominate the plant community.

## Transition T2B
## State 2 to 4

The Contemporary Reference State (2) transitions to the Invaded State (4) when aggressive perennial grasses or noxious weeds displace native species. The most common concerns are crested wheatgrass, introduced bluegrasses, and smooth brome, which are widespread invasive species in the Northern Great Plains (Henderson and Naeth, 2005; Toledo et al., 2014). The precise triggers of this transition are not clear, but data suggest that exclusion of grazing and fire may be a contributing factor in some cases (DeKeyser et al., 2013). In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered.

### Transition T2C
### State 2 to 5

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Contemporary Reference State (2) to the Cropland State (5).

### Restoration pathway R3A
### State 3 to 2

A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of shortgrasses in the Shortgrass State (3) (Dormaar and Willms, 1990). Blue grama, in particular, can resist displacement by other species (Dormaar and Willms, 1990; Laycock, 1991; Dormaar et al., 1994; Lacey et al., 1995). Intensive management, such as reseeding and mechanical treatment, may be necessary (Hart et al., 1985), but these practices are labor intensive and costly. Therefore, returning the Shortgrass State (3) to the Contemporary Reference State (2) may require considerable energy and cost and may not be feasible within a reasonable amount of time.

### Transition T3B
### State 3 to 5

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Shortgrass State (3) to the Cropland State (5).

### Transition T4A
### State 4 to 5

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Invaded State (4) to the Cropland State (5).

### Transition T5A
### State 5 to 6

The transition from the Cropland State (5) to the Post-Cropland State (6) occurs with the cessation of cultivation. The site may also be seeded to perennial forage species. Such seedings may be comprised of introduced grasses and legumes or a mix of native species.

### Transition T6A
### State 6 to 5

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Post-Cropland State (6) to the Cropland State (5).

## Additional community tables

## Inventory data references

No field plots were available for this site. A review of the scientific literature and professional experience was used to approximate the plant communities for this provisional ecological site. Information for the state-and-transition model was obtained from the same sources. All community phases are considered provisional based on these plots and the sources identified 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 | 05/12/2025 |
| Approved by | Kirt Walstad |
| Approval date | |
| Composition (Indicators 10 and 12) based on | Annual Production |

## Indicators

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

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

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

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

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

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

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

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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

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

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

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

17. **Perennial plant reproductive capability:**