Ecological site FX053A99X006
Claypan (Cp)

Last updated: 11/22/2023
Accessed: 10/12/2024

General information

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

MLRA notes

Major Land Resource Area (MLRA): 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

NRCS Soil Geography Hierarchy
• Land Resource Region: Northern Great Plains
• Major Land Resource Area (MLRA): 053A Northern Dark Brown Glaciated Plains

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 and Shrubland Division (2.B.2.Nb)
• Macrogroup: *Hesperostipa comata* - *Pascopyrum smithii* - Festuca hallii Grassland Macrogroup (2.B.2.Nb.2)
o Group: *Hesperostipa comata* - *Bouteloua gracilis* Dry Mixedgrass Prairie Group (2.B.2.Nb.2.b)

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

Claypan is an ecological site of limited extent site occurring on till plains, moraines, and fans in MLRA 53A. The distinguishing characteristic of this site is the presence of a dense, sodium-affected (natric) horizon between depths of 5 to 10 inches from the surface. The natric horizon exhibits columnar structure, is very hard, and severely limits both root penetration and infiltration. Soils for this ecological site are typically moderately deep to very deep (more than 20 inches to bedrock), well drained, and derived from till or glaciofluvial deposits. Characteristic vegetation is rhizomatous wheatgrasses, needle and thread (*Hesperostipa comata*), and blue grama (*Bouteloua gracilis*).

Associated sites

FX053A99X145	**Panspot (Pn)** The Panspot site is on the lowest microtopography whereas the Claypan site occupies higher positions.
FX053A99X165	**Thin Claypan (TCp)** The Thin Claypan site is on lower microtopography, between areas of the Claypan and Panspot sites.
FX053A99X032	**Loamy (Lo)** The Loamy site is on the highest microtopography whereas the Claypan site is somewhat lower.

Similar sites

FX053A99X165	**Thin Claypan (TCp)** This site differs from the Claypan site in that the root-restricting layer (evidenced by columnar structure) is more than 1 inch to 4 inches below the soil surface.
FX053A99X032	**Loamy (Lo)** This site differs from the Claypan site in that the root-restricting layer (evidenced by columnar structure) is either absent or more than 10 inches below the soil surface.
FX053A99X145	**Panspot (Pn)** This site differs from the Claypan site in that the root-restricting layer (evidenced by columnar structure) is 1 inch or less from the surface.

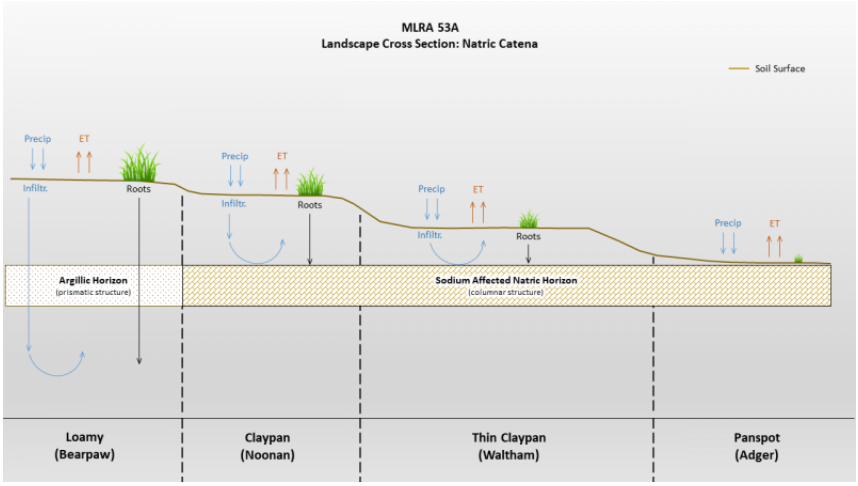


Figure 1. Diagram of similar and associated sites

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Pascopyrum smithii* (2) *Bouteloua gracilis*

Legacy ID

R053AY702MT

Physiographic features

This ecological site occurs on nearly level to gently sloping till plains, moraines, outwash fans, and alluvial fans. The slopes typically range from 0 to 15 percent but are generally less than 8 percent.

Table 2. Representative physiographic features

Geomorphic position, flats	(1) Talf (2) Rise
Landforms	(1) Till plain > Moraine (2) Till plain > Fan
Flooding frequency	None
Ponding frequency	None
Elevation	1,800–3,300 ft
Slope	0–8%
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Flooding frequency	Not specified
Ponding frequency	Not specified
Elevation	Not specified
Slope	0–14%

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 4. Representative climatic features

Frost-free period (characteristic range)	90-130 days
Freeze-free period (characteristic range)	115-155 days
Precipitation total (characteristic range)	11-15 in
Frost-free period (average)	110 days
Freeze-free period (average)	135 days
Precipitation total (average)	13 in

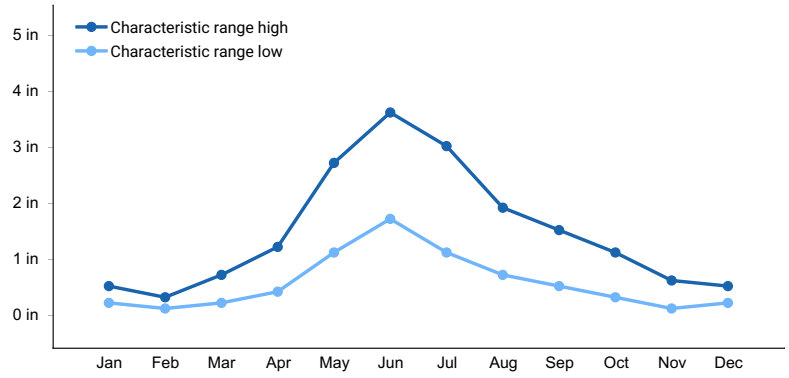


Figure 2. Monthly precipitation range

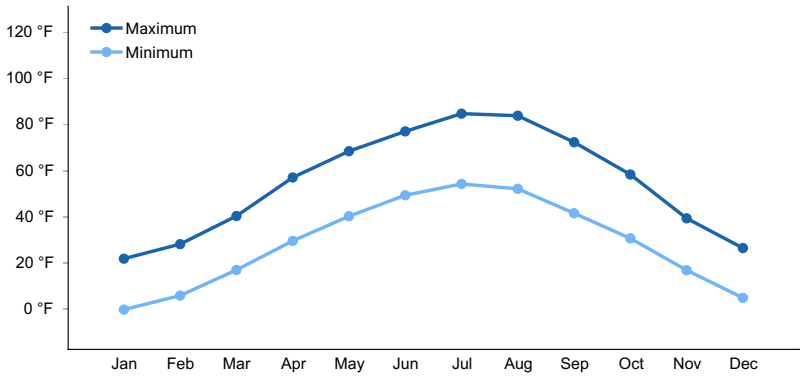


Figure 3. Monthly average minimum and maximum temperature

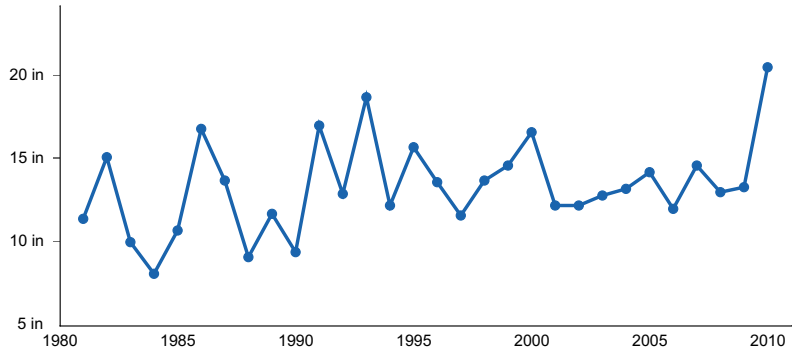


Figure 4. Annual precipitation pattern

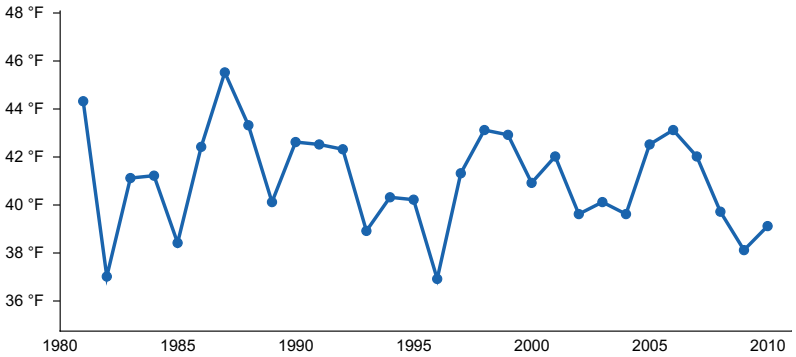


Figure 5. Annual average temperature pattern

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, but it has unique hydrology because infiltration is severely limited by the dense natric horizon 4 to 10 inches below the soil surface. Evapotranspiration exceeds precipitation on this site, and a state of moisture deficit persists for the majority of the year. In typical precipitation events, the upper 4 to 10 inches of the soil profile is filled to field capacity, then moisture amounts are quickly diminished by evapotranspiration. Abnormally wet years or very intense precipitation events can saturate the soil surface layer and cause very brief (less than 2 days) ponding and lateral flow via surface runoff into adjacent microlows. Lateral water movement is typically limited to a localized area due to the flat topography. Frequency and duration of saturation are not sufficient for the development of hydric soil features.

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 till 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 textures found in this site are most frequently loam but can range from fine sandy loam to silty clay loam

and typically contain between 15 to 30 percent clay. The underlying natric horizons typically contain 35 to 50 percent clay and have clay, clay loam, or silty clay loam textures. Calcium carbonate equivalent is typically less than 5 percent in the upper 5 inches and typically less than 10 percent in lower horizons. In the upper 20 inches, electrical conductivity is at some point more than 4 and the sodium absorption ratio is typically less than 15. 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 and typically less than 15 percent.

Table 5. Representative soil features

Parent material	(1) Till–igneous, metamorphic and sedimentary rock (2) Alluvium–igneous, metamorphic and sedimentary rock
Surface texture	(1) Loam (2) Fine sandy loam (3) Silty clay loam
Drainage class	Well drained
Depth to restrictive layer	4–10 in
Soil depth	20–72 in
Electrical conductivity (0-20in)	2–8 mmhos/cm
Sodium adsorption ratio (0-20in)	0–15
Subsurface fragment volume <=3" (0-20in)	0–34%
Subsurface fragment volume >3" (0-20in)	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 Claypan 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 blue grama (*Bouteloua gracilis*) (Smoliak et al., 1972; Smoliak, 1974). 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 such as blue grama and prairie Junegrass (Koeleria cristata).

Most, if not all, extant examples of this site have some degree of invasion by non-native species. Non-native grasses such as crested wheatgrass (*Agropyron cristatum*), and bluegrass (Poa spp.) are the most common invasive species. These species are widespread throughout the Northern Great Plains and can invade relatively undisturbed grasslands (Heidinga and Wilson, 2002; Henderson and Naeth, 2005; Toledo et al., 2014). In most cases native ecological function is relatively intact, but in some cases non-native grasses will displace native species and dominate the ecological functions of the site.

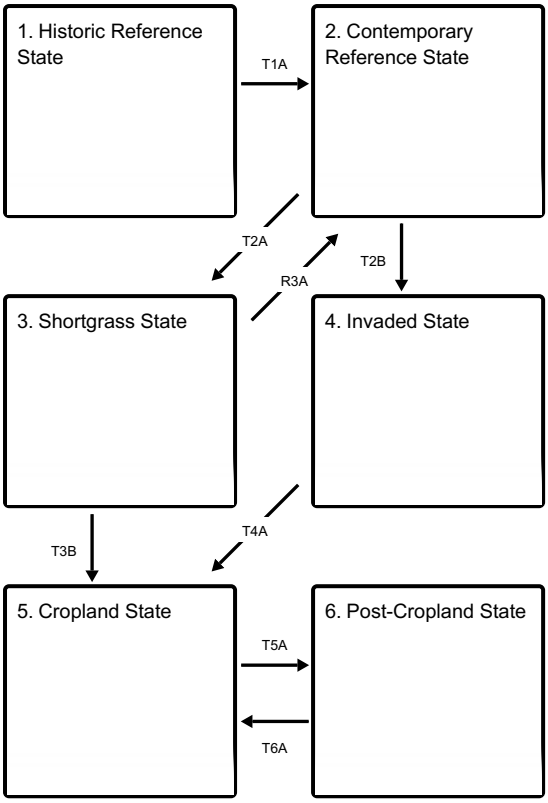
The effects of an altered fire regime are not completely understood at the time of this writing, but evidence suggests that long-term fire suppression can result in accumulations of litter and may contribute to increased abundance of non-native grasses (Murphy and Grant, 2005; Vermeire et al., 2011; 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 Claypan 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.

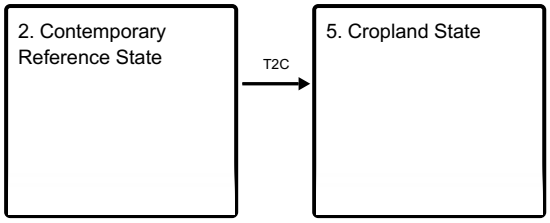
The state-and-transition model (STM) (Figure 3) suggests possible pathways that plant communities on this site may follow as a result of a given set of ecological processes and management. The site may also support states not displayed in the STM diagram. Landowners and land managers should seek guidance 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 crested wheatgrass and Kentucky bluegrass.

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

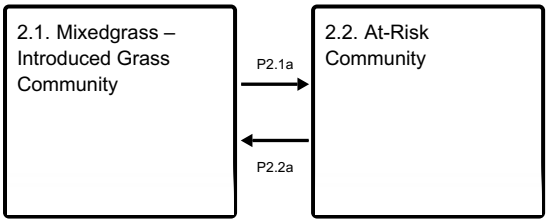
T4A - Conversion to cropland

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

3.1. Shortgrass Community

State 4 submodel, plant communities

4.1. Invaded Community

State 5 submodel, plant communities

5.1. Cropland Community

State 6 submodel, plant communities

6.1. Abandoned Cropland Community

6.2. Perennial Grass Community

State 1
Historic Reference State

The Historic Reference State (1) contains one community phase characterized by mid-statured rhizomatous wheatgrasses, shortgrasses, and mid-statured bunchgrasses. 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 short-term shifts in species composition to more warm-season grasses such as blue grama and fewer cool-season bunchgrasses.

Community 1.1
Mixedgrass Community

The Mixedgrass Community Phase (1.1) was characterized by a predominance of mid-statured rhizomatous wheatgrasses. 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 needle and thread (*Hesperostipa comata*) was common, although not abundant (Coupland, 1950, 1961; Heidel et al., 2000). Blue grama (*Bouteloua gracilis*) and prairie Junegrass (*Koeleria macrantha*) were the dominant shortgrasses. Forbs comprised about 10 percent of the cover and shrubs about 5 percent or less.

State 2
Contemporary Reference State

The Contemporary Reference State (2) contains two community phases characterized by mid-statured rhizomatous wheatgrasses, shortgrasses, and mid-statured bunchgrasses. 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
Mixedgrass – Introduced Grass Community

The Mixedgrass - Introduced Grass Community Phase (2.1) is predominantly native species, but it has some degree of non-native grass establishment. It is characterized by a predominance of mid-statured rhizomatous wheatgrasses. 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 needle and thread is common but typically does not exceed 10 percent of the plant community composition. The dominant shortgrasses are blue grama and 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 needle and thread are rare or absent. Shortgrasses such blue grama and 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 Mixedgrass – Introduced Grass Community (2.1) to the At-Risk Community (2.2). These factors favor an increase in shortgrasses such as blue grama and 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 needle and thread have been largely eliminated. Short-statured species such as blue grama and prairie Junegrass 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 such as blue grama. Depending on the historical management of the site, perennial bunchgrasses such as needle and thread 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 blue grama and prairie Junegrass 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 and introduced bluegrasses, 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

One medium-intensity field plot was available for this site. This plot, in conjunction with 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.

Other references

Anderson, R.C. 2006. Evolution and origin of the central grassland of North America: Climate, fire, and mammalian grazers. Journal of the Torrey Botanical Society 133:626-647.

Biondini, M.E., and L. Manske. 1996. Grazing frequency and ecosystem processes in a northern mixed prairie, USA. Ecological Applications 6:239-256.

Biondini, M.E., B.D. Patton, and P.E. Nyren. 1998. Grazing intensity and ecosystem processes in a northern mixed-

grass prairie, USA. Ecological Applications 8:469-479.

Bragg, T.B. 1995. The physical environment of the Great Plains grasslands. In: A. Joern and K.H. Keeler (eds.) The Changing Prairie, Oxford University Press, Oxford, pp. 49-81.

Christian, J.M., and S.D. Wilson. 1999. Long-term ecosystem impacts of an introduced grass in the Northern Great Plains. Ecology 80:2397-2407.

Clarke, S.E, E.W. Tisdale, and N.A. Skoglund. 1947. The effects of climate and grazing practices on short-grass prairie vegetation in southern Alberta and southwestern Saskatchewan. Canadian Department of Agriculture Technical Bulletin No. 46.

Cleland, D.T., et al. 1997. National hierarchical framework of ecological units. In: M.S. Boyce and A. Haney (eds.) Ecosystem Management Applications for Sustainable Forest and Wildlife Resources, Yale University Press, New Haven, CT.

Coupland, R.T. 1950. Ecology of the mixed prairie of Canada. Ecological Monographs 20:271-315.

Coupland, R.T. 1958. The effects of fluctuations in weather upon the grasslands of the Great Plains. Botanical Review 24:273-317.

Coupland, R.T. 1961. A reconsideration of grassland classification in the Northern Great Plains of North America. Journal of Ecology 49:135-167.

Coupland, R.T., and R.E. Johnson. 1965. Rooting characteristics of native grassland species in Saskatchewan. Journal of Ecology 53:475-507.

DeKeyser, E.S., M. Meehan, G. Clambey, and K. Krabbenhoft. 2013. Cool season invasive grasses in Northern Great Plains natural areas. Natural Areas Journal 33:81-90.

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

Derner, J.D., and R.H. Hart. 2007. Grazing-induced modifications to peak standing crop in northern mixed-grass prairie. Rangeland Ecology and Management 60:270-276.

Dix, R.L. 1960. The effects of burning on the mulch structure and species composition of grasslands in western North Dakota. Ecology 41:49-56.

Dormaar, J.F., and S. Smoliak. 1985. Recovery of vegetative cover and soil organic matter during revegetation of abandoned farmland in a semiarid climate. Journal of Range Management 38:487-491.

Dormaar, J.F., and W.D. Willms. 1990. Effect of grazing and cultivation on some chemical properties of soils in the mixed prairie. Journal of Range Management 43:456-460.

Dormaar, J.F., S. Smoliak, and W.D. Willms. 1990. Soil chemical properties during succession from abandoned cropland to native range. Journal of Range Management 43:260-265.

Dormaar, J.F., B.W. Adams, and W.D. Willms. 1994. Effect of grazing and abandoned cultivation on a Stipa-Bouteloua community. Journal of Range Management 47:28-32.

Dormaar, J.F., M.A. Naeth, W.D. Willms, and D.S. Chanasyk. 1995. Effect of native prairie, crested wheatgrass (*Agropyron cristatum*) and Russian wildrye (Elymus junceus) on soil chemical properties. Journal of Range Management 48:258-263.

Federal Geographic Data Committee. 2008. The National Vegetation Classification Standard, Version 2. FGDC Vegetation Subcommittee. FGDC-STD-005-2008 (Version 2), p. 126.

Fullerton, D.S., and R.B. Colton. 1986. Stratigraphy and correlation of the glacial deposits on the Montana Plains. U.S. Geological Survey.

Fullerton, D.S., R.B. Colton, C.A. Bush, and A.W. Straub. 2004. Map showing spatial and temporal relations of mountain and continental glaciations on the northern plains, primarily in northern Montana and northwestern North Dakota. U.S. Geologic Survey pamphlet accompanying Scientific Investigations Map 2843.

Grant, T.A., B. Flanders-Wanner, T.L. Shaffer, R.K. Murphy, and G.A. Knutsen. 2009. An emerging crisis across northern prairie refuges: Prevalence of invasive plants and a plan for adaptive management. Ecological Restoration 27:58-65.

Hart, M., S.S. Waller, S.R. Lowry, and R.N. Gates. 1985. Disking and seeding effects on sod bound mixed prairie. Journal of Range Management 38:121-125.

Heidel, B., S.V. Cooper, and C. Jean. 2000. Plant species of special concern and plant associations of Sheridan County, Montana. Report to U.S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena, MT.

Heidinga, L., and S.D. Wilson. 2002. The impact of an invading alien grass (*Agropyron cristatum*) on species turnover in native prairie. Diversity and Distributions 8:249-258.

Heitschmidt, R.K., and L.T. Vermeire. 2005. An ecological and economic risk avoidance drought management decision support system. In: J.A. Milne (ed.) Pastoral Systems in Marginal Environments, XXth International Grasslands Congress, July 2005, p. 178.

Henderson, D.C., and M.A. Naeth. 2005. Multi-scale impacts of crested wheatgrass invasion in mixed-grass prairie. Biological Invasions 7:639-650.

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2009. Monitoring manual for grassland, shrubland and savanna ecosystems. U.S. Department of Agriculture, Agricultural Research Service, Jornada Experimental Range, Las Cruces, NM.

Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish and Wildlife Service Resource Publication 161.

Holechek, J.L. 1981. Crested wheatgrass. Rangelands 3:151-153.

Knopf, F.L. 1996. Prairie legacies—birds. In: F.B. Samson and F.L. Knopf (eds.) Prairie Conservation: Preserving North America's Most Endangered Ecosystem, Island Press, Washington, DC, pp. 135-148.

Knopf, F.L., and F.B. Samson. 1997. Conservation of grassland vertebrates. In: F.B. Samson and F.L. Knopf (eds.) Ecology and Conservation of Great Plains Vertebrates: Ecological Studies 125, Springer-Verlag, New York, NY, pp. 273-289.

Krzic, M., K. Broersma, D.J. Thompson, and A.A. Bomke. 2000. Soil properties and species diversity of grazed crested wheatgrass and native rangelands. Journal of Range Management 53:353-358.

Lacey, J., R. Carlstrom, and K. Williams. 1995. Chiseling rangeland in Montana. Rangelands 17:164-166.

Laycock, W.A. 1991. Stable states and thresholds of range condition on North American rangelands. Journal of Range Management 44:427-433.

Lockwood, J.A. 2004. Locust: The devastating rise and mysterious disappearance of the insect that shaped the American frontier. Basic Books, New York, NY.

McNab, W.H., et al. 2007. Description of ecological subregions: Sections of the conterminous United States [CD-ROM]. USDA Forest Service, General Technical Report WO-76B.

Montana State College. 1949. Similar vegetative rangeland types in Montana. Montana State College, Agricultural

Experiment Station.

Murphy, R.K., and T.A. Grant. 2005. Land management history and floristics in mixed-grass prairie, North Dakota, USA. Natural Areas Journal 25:351-358.

Nesser, J.A., G.L. Ford, C.L. Maynard, and D.S. Page-Dumroese. 1997. Ecological units of the Northern Region: Subsections. USDA Forest Service, Intermountain Research Station, General Technical Report INT-GTR-369.

Ogle, S.M., W.A. Reiners, and K.G. Gerow. 2003. Impacts of exotic annual brome grasses (Bromus spp.) on ecosystem properties of the northern mixed grass prairie. American Midland Naturalist 149:46-58.

Richardson, R.E., and L.T. Hanson. 1977. Soil survey of Sheridan County, Montana. USDA Soil Conservation Service, Bozeman, MT.

Rogler, G.A., and R.J. Lorenz. 1983. Crested wheatgrass: Early history in the United States. Journal of Range Management 36:91-93.

Romo, J.T. 2011. Clubmoss, precipitation, and microsite effects on emergence of graminoid and forb seedlings in the semiarid Northern Mixed Prairie of North America. Journal of Arid Environments 75:98-105.

Romo, J.T., and Y. Bai. 2004. Seedbank and plant community composition, Mixed Prairie of Saskatchewan. Journal of Range Management 57:300-304.

Rowe, J.S. 1969. Lightning fires in Saskatchewan grassland. Canadian Field Naturalist 83:317-327.

Salo, E.D., et al. 2004. Grazing intensity effects on vegetation, livestock and non-game birds in North Dakota mixed-grass prairie. Proceedings of the 19th North American Prairie Conference, Madison, WI.

Samuel, M.J., and R.H. Hart. 1994. Sixty-one years of secondary succession on rangelands of the Wyoming High Plains. Journal of Range Management 47:184-191.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils. Version 3.0. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Shay, J., D. Kunec, and B. Dyck. 2001. Short-term effects of fire frequency on vegetation composition and biomass in mixed prairie in south-western Manitoba. Plant Ecology 155:157-167.

Smith, B., and G.J. McDermid. 2014. Examination of fire-related succession within the dry mixed-grass subregion of Alberta with the use of MODIS and Landsat. Rangeland Ecology and Management 67:307-317.

Smoliak, S. 1974. Range vegetation and sheep production at three stocking rates on Stipa-Bouteloua prairie. Journal of Range Management 27:23-26.

Smoliak, S., J.F. Dormaar, and A. Johnston. 1972. Long-term grazing effects on Stipa-Bouteloua prairie soils. Journal of Range Management 25:246-250.

Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th edition. USDA Natural Resources Conservation Service.

Soller, D.R. 2001. Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains. U.S. Geological Survey Miscellaneous Investigations Series I-1970-E, scale 1:3,500,000.

Toledo, D., M. Sanderson, K. Spaeth, J. Hendrickson, and J. Printz. 2014. Extent of Kentucky bluegrass and its effect on native plant species diversity and ecosystem services in the Northern Great Plains of the United States. Invasive Plant Science and Management 7:543-552.

U.S. Department of Agriculture, National Agricultural Statistics Service. 2017. Montana Annual Bulletin, Volume LIV,

Issue 1095-7278.
https://www.nass.usda.gov/Statistics_by_State/Montana/Publications/Annual_Statistical_Bulletin/2017/Montana_Annual_Bulletin_2017.pdf (Accessed 14 February 2017).

U.S. Department of Agriculture, Natural Resources Conservation Service. Glossary of landform and geologic terms. National Soil Survey Handbook, Title 430-VI, Part 629.02c.
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242 (Accessed 13 April 2016).

Van Dyne, G.M., and W.G. Vogel. 1967. Relation of Selaginella densa to site, grazing, and climate. Ecology 48:438-444.

Vaness, B.M., and S.D. Wilson. 2007. Impact and management of crested wheatgrass (*Agropyron cristatum*) in the northern Great Plains. Canadian Journal of Plant Science 87:1023-1028.

Vermeire, L.T., J.L. Crowder, and D.B. Wester. 2011. Plant community and soil environment response to summer fire in the northern Great Plains. Rangeland Ecology and Management 64:37-46.

Vermeire, L.T., J.L. Crowder, and D.B. Wester. 2014. Semiarid rangeland is resilient to summer fire and postfire grazing utilization. Rangeland Ecology and Management 67:52-60.

Vuke, S.M., K.W. Porter, J.D. Lonn, and D.A. Lopez. 2007. Geologic map of Montana - information booklet: Montana Bureau of Mines and Geology Geologic Map 62-D.

Whisenant, S.G. 1990. Postfire population dynamics of Bromus japonicus. American Midland Naturalist 123:301-308.

Wilson, S.D., and J.M. Shay. 1990. Competition, fire, and nutrients in a mixed-grass prairie. Ecology 71:1959-1967.

Contributors

Scott Brady
Stuart Veith

Approval

Kirt Walstad, 11/22/2023

Acknowledgments

A number of USDA-NRCS staff supported this project. Staff contributions are as follows:

Soil Concepts, Soils Information, and Field Descriptions
Charlie French, USDA-NRCS (retired)
Steve Sieler, USDA-NRCS

NASIS Reports, Data Dumps, and Soil Sorts
Bill Drummond, USDA-NRCS (retired)
Pete Weikle, USDA-NRCS

Peer Review
Kirt Walstad, USDA-NRCS
Mark Hayek, USDA-NRCS
Kami Kilwine, USDA-NRCS
Robert Mitchell, USDA-NRCS

Quality Control
Kirt Walstad, USDA-NRCS

Quality Assurance
Stacey Clark, USDA-NRCS

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	10/12/2024
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:**