USDA Natural Resources
Conservation Service

Ecological site FX052X01X165
Thin Claypan (Tcp) Dry Grassland

Last updated: 2/12/2025
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.

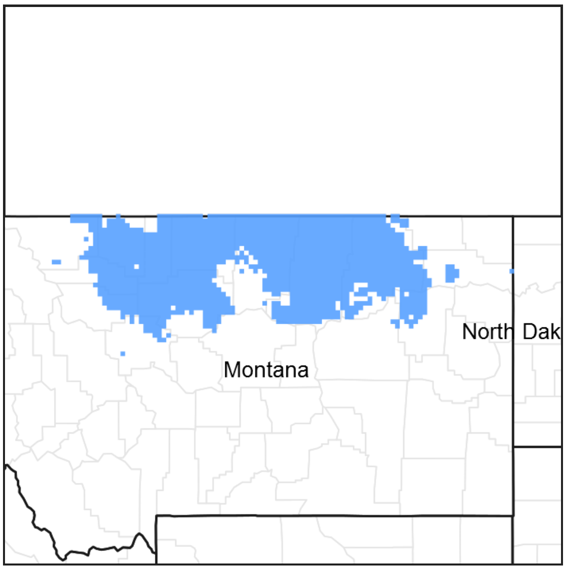


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 052X–Brown Glaciated Plains

The Brown Glaciated Plains, MLRA 52, is an expansive and agriculturally and ecologically significant area consisting of around 14.5 million acres that stretches across 350 miles from east to west, encompassing portions of 15 counties in north-central Montana. This region represents the southwestern limit of the Laurentide Ice Sheet and is considered to be the driest and westernmost area within the vast network of glacially-derived prairie pothole landforms of the northern Great Plains. The elevation ranges from 2,000 feet (610 meters) to 4,600 feet (1,400 meters).

Soils are primarily Mollisols but Entisols, Inceptisols, Alfisols and Vertisols are also common. Till from continental glaciation is the predominant parent material but alluvium and bedrock are also frequently encountered. Till deposits are typically less than 50 feet thick and in some areas glacially deformed bedrock can be found at or near the soil surface (Soller 2001). Underlying sedimentary bedrock largely consisting of Cretaceous shale, sandstone and mudstone (Vuke et al. 2007) is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur along glacial outwash channels and major drainages, which include portions of the Missouri, Teton, Marias, Milk and Frenchman Rivers. Large glacial lakes, particularly in the western half of the MLRA, deposited clayey and silty lacustrine sediments (Fullerton et al. 2013).

Much of the western portion of this MLRA was glaciated towards the end of the Wisconsin age with the maximum glacial extent occurring approximately 20,000 years ago (Fullerton et al. 2004). The result is a geologically young landscape that is predominantly a level till plain interspersed with lake plains and dominated by soils in the Mollisol and Vertisol orders. These soils are very productive and generally are well-suited to dryland farming. Much of this area is aridic-ustic and crop-fallow dryland wheat farming is the predominant land use, with rangeland typically being found on steep hillslopes along drainages.

Rangeland, much of it is native mixed grass prairie, increases in abundance in the eastern half of the MLRA. The Wisconsin-age till in the north-central part of this area typically formed large disintegration moraines with steep slopes and numerous poorly-drained potholes. A large portion of Wisconsin-age till that is found on this type of terrain, that would typically be optimal for farming, has large amounts of less-suitable sodium-affected Natrustalfs. Significant portions of Blaine, Phillips, and Valley Counties were glaciated approximately 150,000 years ago during the Illinoisan age and, due to erosion and dissection of the landscape, much of these areas have steeper slopes and more exposed bedrock than areas glaciated during the Wisconsin age (Fullerton et al. 1986).

While much of the rangeland in the aridic ustic portion of MLRA 52 is classified as belonging to the ‘dry grassland’ climatic zone, sites in portions of southern MLRA 52 may belong to the ‘dry shrubland’ climatic zone. The dry shrubland zone represents the northernmost extent of big sagebrush (Artemisia tridentata) steppe on the Great Plains. As similar soils occur in both southern and northern portions of the MLRA, it is currently hypothesized that climate is the primary driving factor affecting big sagebrush distribution in this area, but the precise factors have so far proven to be elusive and are, for the time of this writing, not yet fully understood.

Sizable tracts of largely unbroken rangeland in the eastern half of the MLRA and adjacent southern Saskatchewan are home to the Northern Montana Population of Greater Sage Grouse (Centrocercus urophasianus) and large portions of this area are considered to be a Priority Area for Conservation (PAC) by the U.S. fish and Wildlife Service (U.S. Fish and Wildlife Service 2013). This population is unique among sage grouse populations in the fact that many individuals overwinter in the big sagebrush steppe (dry shrubland) in the southern portion of the MLRA and then migrates to the northern portion of the MLRA which lacks big sagebrush (dry grassland) to spend rest of the year (Smith 2013).

Areas of the till plain near the Bearpaw and Highwood Mountains as well as the Sweetgrass Hills and Rocky Mountain foothills are at higher elevations and receive higher amounts of precipitation and have a typic-ustic moisture regime. These areas have significantly more rangeland production than the drier aridic-ustic portions of the MLRA and have enough moisture to produce crops annually as opposed to biennially in the drier areas. Ecological sites in this higher precipitation area are classified as the moist grassland climatic zone.

Classification relationships

NRCS Soil Geography Hierarchy
Land Resource Region: Northern Great Plains
Major Land Resource Area: 52
Climatic Zone: Dry Grassland

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: Northwestern Glaciated Plains 331D
• Subsection: Montana Glaciated Plains 331Dh
• 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, Meadow, and Shrubland Formation (2.B.2)
• Division: Great Plains 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 – Bouteloua spp. Mixedgrass Prairie Group (2.B.2.Nb.2.c)

• Alliance: Pascopyrum smithii – Nassella viridula Northwestern Great Plains Herbaceous Alliance
• Association: Pascopyrum smithii –Bouteloua gracilis – Carex filifolia Herbaceous Vegetation

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

Ecological site concept

The Thin Claypan ecological site occurs on till plains, moraines and fans, generally on slopes less than eight percent or less. The site is characterized by a dense root restricting layer (evidenced by columnar structure) that is between one (1) and four (4) inches from the soil surface. The surface texture is typically loam over clay or clay loam. Vegetation is dominated by western wheatgrass (Pascopyrum smithii) and/or thickspike wheatgrass (Elymus lanceolatus). Less common grasses include plains reedgrass (Calamagrostis montanensis), blue grama (Bouteloua gracilis), prairie Junegrass (Koeleria macrantha) and Sandberg bluegrass (Poa secunda). Silver sagebrush is the most common shrub. This site is typically associated with Panspot and Claypan ecological sites. Figure 2 illustrates the distribution of this ecological site based on current data. This map is approximate, is not intended to be definitive, and may be subject to change. Field verification using the appropriate MLRA key is required for proper identification of this ecological site.

Associated sites

FX052X01X006	**Claypan (Cp) Dry Grassland** Claypan is found on higher micro topography than Thin Claypan, but lower than Loamy.
FX052X01X032	**Loamy (Lo) Dry Grassland** Loamy is found on the highest micro topography whereas Thin Claypan is much lower.
FX052X01X145	**Panspot (Pn) Dry Grassland** Panspot is found on the lowest micro topography whereas Thin Claypan occupies higher positions.

Similar sites

FX052X03X165	**Thin Claypan (Tcp) Dry Shrubland** Differs from Thin Claypan Dry Grassland in that annual temperatures are slightly warmer and site supports big sagebrush rather than silver sagebrush.
FX052X01X145	**Panspot (Pn) Dry Grassland** Differs from Thin Claypan in that the root restricting layer (evidenced by columnar structure) is 1 inch or less from the surface.
FX052X01X006	**Claypan (Cp) Dry Grassland** Differs from Thin Claypan in that the root restricting layer (evidenced by columnar structure) is greater than 4 inches to 10 inches below the soil surface.
FX052X01X032	**Loamy (Lo) Dry Grassland** Differs from Thin Claypan in that the root restricting layer (evidenced by columnar structure) is either absent or greater than 10 inches below the soil surface.

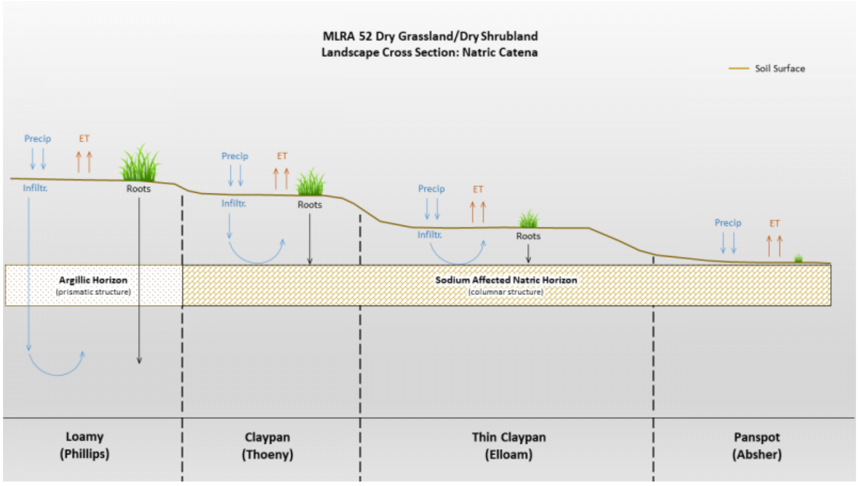


Figure 2. Associated and Similar Sites Diagram

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Pascopyrum smithii*

Legacy ID

R052XY165MT

Physiographic features

The Thin Claypan Dry Grassland ecological site is a common ecological site occurring on moraines, outwash fans and terraces. This site is extensive across MLRA 52 but is most prevalent on the Havre lobe and the contiguous Malta sublobe, which, when combined, stretch from southeastern Alberta and southwestern Saskatchewan through northeastern Hill, central Blaine and southern Phillips Counties. Much of this lobe consists of an extensive ground moraine with slopes of 0 to 4 percent. The till incorporated physical and chemical properties of the underlying clayey Bearpaw shale, which in MLRA 52 tends to have appreciable amounts of sodium, magnesium and calcium sulfates but little to no calcium carbonate.

It is hypothesized that during and immediately after deglaciation, the combination of water-restricting bedrock underlying the sodium-rich clayey till at depths of 10 feet or less combined with the gentler slopes of the till plain created an ideal situation where water could pond and move, by matric potential to concentrate enough salts to create the natric horizon and its distinctive columnar structure (Miller and Brierly, 2011). The present-day hydrology of this site lacks a water table. As is the case with the Thin Claypan site, complex micro relief is normal on landforms dominated by natric soils. In relation to the Panspot ecological site, the Thin Claypan is found on microhighs, whereas when in complex with Claypan or Loamy sites is found on microlows.

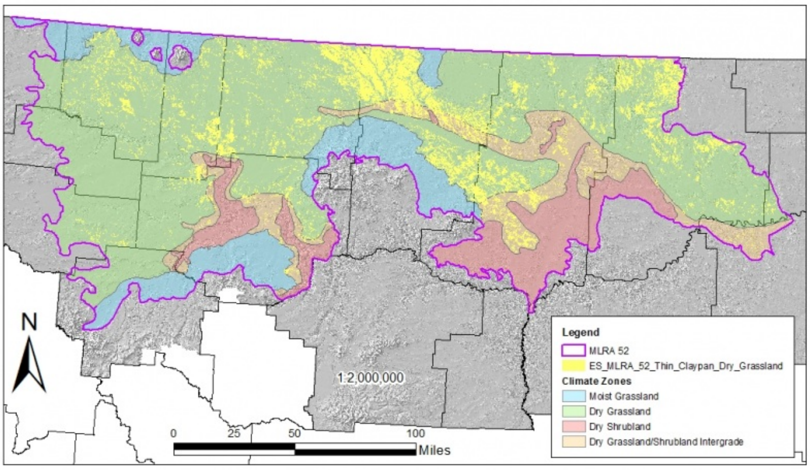


Figure 3. Extent of the Thin Claypan Dry Grassland Ecological Site within MLRA 52 based on soil mapunit component.

Table 2. Representative physiographic features

Landforms	(1) Till plain > Moraine (2) Till plain > Outwash fan (3) Terrace
Elevation	2,000–3,870 ft
Slope	0–8%
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Elevation	2,000–3,870 ft
Slope	0–14%

Climatic features

The Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Cooper et al., 2001). The average frost-free period for this ecological site is 120 days. 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. Severe drought occurs on average in 2 out of every 10 years. Annual precipitation ranges from 10 to 14 inches, and 70 to 80 percent of this occurs during the growing season (Cooper et al., 2001). Extreme climatic variations, especially droughts, have the greatest influence on species cover and production (Coupland, 1958, 1961; Biondini et al., 1998).

During the winter months, the western half of MLRA 52 commonly experiences chinook winds, which are strong west to southwest surface winds accompanied by abrupt increases in temperature. The chinook winds are strongest on the western boundary of the MLRA near the Rocky Mountain foothills and decrease eastward. In addition to producing damaging winds, prolonged chinook episodes can result in drought or vegetation kills due to the reaction of plants to a “false spring” (Oard, 1993).

Table 4. Representative climatic features

Frost-free period (average)	120 days
Freeze-free period (average)	140 days
Precipitation total (average)	12 in

Climate stations used

- (1) CARTER 14 W [USC00241525], Floweree, MT
- (2) CHESTER [USC00241692], Chester, MT
- (3) TIBER DAM [USC00248233], Chester, MT
- (4) HARLEM [USC00243929], Harlem, MT
- (5) MALTA 7 E [USC00245338], Malta, MT
- (6) TURNER 11N [USC00248415], Turner, MT
- (7) CONRAD [USC00241974], Conrad, MT
- (8) SHELBY [USC00247500], Shelby, MT
- (9) GLASGOW [USW00094008], Glasgow, MT
- (10) HAVRE CITY CO AP [USW00094012], Havre, MT

Influencing water features

This site is not influenced by a groundwater table. Infiltration is limited by a dense clay layer near the soil surface. Moisture loss through potential evapotranspiration exceeds precipitation for the majority of the growing season. Except for May and June, the site is generally in a state of moisture deficit.

Soil features

The soil that best represents the central concept for this ecological site is the benchmark Elloam series, which covers over 780,000 acres of MLRA 52. This soil is in the Natrustalfs Great Group and is characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon and by a dense, root-limiting, non-cemented restrictive layer 1 to 4 inches below the soil surface. This restrictive layer is referred to as a natric horizon and is essentially an argillic horizon that has been affected by sodium salts. The natric horizon exhibits a distinctive columnar structure that is especially visible when the soil is dry. Elloam is a fine family and has smectitic mineralogy. Clayey till (28 to 42 percent clay) is the typical parent material for this series, but the Thin Claypan ecological sit may also occur on soils derived from glaciofluvial deposits, shale residuum, or till over residuum. The soil moisture regime for this and all soils in this ecological site concept is ustic bordering on aridic, 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. These soils have 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 usually contain between 15 and 30 percent clay. The underlying natric horizons typically contain 35 to 50 percent clay and have clay, clay loam or silty clay loam textures. Organic matter in the surface horizon typically ranges from one to two percent and moist colors vary from brown (10YR 5/3) to dark grayish brown (10YR 4/2). The surface of these soils does not typically react with hydrochloric acid. The depth to secondary carbonates and soluble sulfate salts is usually between five and eight inches below the soil surface. Calcium carbonate equivalent in the soil surface five inches is typically less than five percent and typically less than 10 percent in lower horizons. In the soil surface 20 inches, electrical conductivity is, at some point, more than two and less than eight and the sodium absorption ratio is typically less than 15. These salts lower the amount of plant-available water. Soil pH classes are moderately acidic to slightly alkaline in the surface horizon and neutral to strongly alkaline in the subsurface horizons. The soil depth class for this site can be moderately deep (between 20 and 40 inches to bedrock) in places where bedrock is present but is typically very deep (greater than 60 inches to bedrock). Coarse fragments are less than 35 percent in the upper 20 inches of soil and are typically less than 15 percent.

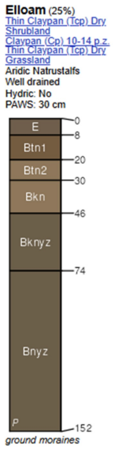


Figure 6. Typical Soil Profile

Table 5. Representative soil features

Parent material	(1) Till (2) Glaciofluvial deposits (3) Residuum
Surface texture	(1) Loam (2) Fine sandy loam (3) Silty clay loam
Family particle size	(1) Fine
Drainage class	Well drained
Depth to restrictive layer	1–4 in
Soil depth	60–72 in
Available water capacity (0-40in)	3–4.7 in
Calcium carbonate equivalent (0-5in)	0–4%
Electrical conductivity (0-20in)	2–8 mmhos/cm
Sodium adsorption ratio (0-20in)	2–15
Soil reaction (1:1 water) (0-40in)	5.6–9
Subsurface fragment volume <=3" (0-20in)	0–14%
Subsurface fragment volume >3" (0-20in)	0–14%

Table 6. Representative soil features (actual values)

Drainage class	Well drained
Depth to restrictive layer	1–4 in
Soil depth	20–72 in
Available water capacity (0-40in)	3–4.7 in
Calcium carbonate equivalent (0-5in)	0–14%

Electrical conductivity (0-20in)	0–8 mmhos/cm
Sodium adsorption ratio (0-20in)	2–15
Soil reaction (1:1 water) (0-40in)	5.6–9
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 Thin Claypan ecological site in MLRA 52 Dry Grassland consists of six states: The Historic Reference State (1.0), the Contemporary Reference State (2.0), the Shortgrass State (3.0), the Invaded State (4.0), Annual Cropland (5.0), and the Post-Cropland State (6.0).

The presumed Historic Reference Community Phase of the Thin Claypan ecological site was dominated by mid-statured, cool-season perennial rhizomatous wheatgrasses. Short-statured, cool-season grasses, particularly prairie Junegrass and Sandberg bluegrass were common on these sites although cover and production were low. The mat-forming, warm-season perennial grass, blue grama was also an important component of this site, although its contribution varied with climate and disturbance. Due to the impermeable nature of the soil, deeper-rooted bunchgrasses such as needle and thread (*Hesperostipa comata*) are not well-adapted to this site (Coupland 1961), although needle and thread did occur as a minor component of the plant community on portions of the site with thicker soil horizons. The species composition and cover of forbs were low on this site. The subshrub prairie, or fringed, sagewort (Artemsia frigida) also had low cover on this site. Plains pricklypear (*Opuntia polyacantha*) was uncommon on this site. Lesser spikemoss (*Selaginella densa*), more locally known and herein after referred to as, dense clubmoss also occurrs on this site, but its cover was highly variable and dependent upon fire frequency, climate, and grazing.

Plant communities associated with the Thin Claypan ecological site evolved under the combined influences of climate, grazing, and fire. Extreme climatic variability results in frequent droughts, which can 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 grasses, annual production is highly dependent upon mid- to late-spring precipitation (Heitschmidt and Vermeire 2005, Anderson 2006).

Native grazers also shaped these plant communities. Bison (Bison bison) were the dominant historic grazers, but pronghorn (Antilocarpa 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.) also 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 historic reference community experienced relatively frequent lightning-caused fires with estimated fire return intervals of six to 25 years (Bragg 1995). Historically, Native Americans also set frequent 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).

Frequent fire is no longer a major disturbance to this ecological site due to fire suppression and cessation of fires ignited by Native Americans. This lack of frequent fires has resulted in an increase in litter accumulation in some areas, providing ideal conditions for seed germination and seedling establishment of non-native annual brome species, such as field, or Japanese, brome (*Bromus arvensis*; Whisenant 1990). These species have become naturalized in relatively undisturbed grasslands, and their presence can reduce the production of cool season perennial grasses (Ogle et al. 2003, Harmoney 2007, Haferkamp et al. 1997). Fire suppression may also be one mechanism that triggers increased cover of dense clubmoss (Rowe 1969, Shay et al. 2001). The cover of dense clubmoss is generally less on recently burned sites; however, its abundance may also vary greatly from site to site without discernable reason (Dix 1960, Wilson and Shay 1990). In general, mechanisms affecting dense clubmoss abundance are not well understood and require further investigation.

Improper grazing of this site can result in a reduction in the cover of the cool season wheatgrasses and, eventually a decrease in other cool-season grasses and an increase in blue grama (Smoliak et al. 1972, Smoliak 1974). Periods of extended drought can reduce mid-statured, cool season, rhizomatous wheatgrasses, shifting 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 Sandberg bluegrass (Adams et al. 2013). Cover of mid-statured rhizomatous grasses and bunchgrasses is severely reduced or absent. Cover of prairie sagewort can increase.

The Thin Claypan ecological site is not generally considered suitable for cropland. However, a good portion of it has been converted to annual cropland despite the soil limitations. Seeding of introduced grasses, particularly crested wheatgrass (*Agropyron cristatum*), was a common practice on eroded and abandoned agricultural areas after the droughts of the 1930s (Rogler and Lorenz 1983). Crested wheatgrass is a highly drought tolerant and competitive cool season, perennial bunchgrass (DeLuca and Lesica 1986). Crested wheatgrass can invade relatively undisturbed grasslands, reducing cover and production of native cool-season midgrasses (Heidinga and Wilson 2002, Henderson and Naeth 2005). Russian wildrye (*Psathyrostachys juncea*), though less widespread, was introduced in the 1950s to provide forage for livestock (Dormaar et al. 1995). Although Russian wildrye is typically planted in monocultures, this species is not considered invasive. Under ideal conditions, it may be able to spread into adjacent degraded plant communities (Ogle et al. 2012), but such conditions are unlikely in MLRA 52.

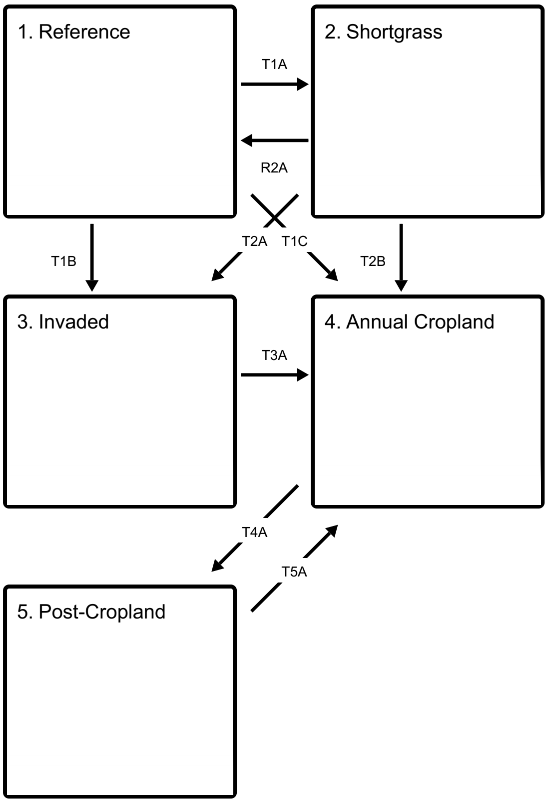
When this site is taken out of production, the site is either allowed to revert to perennial grassland or is seeded with introduced species. Sites left to undergo natural plant succession after cultivation can, over several decades, support blue grama and cool season shortgrasses, although cover and production of these species are lower than in the reference state. However, those sites seeded with non-native species, particularly crested wheatgrass, may persist as this cover type indefinitely (Christian and Wilson 1999).

The STM diagram 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, soil, and aspect. The reference community may not necessarily be the management goal. The lists of plant species, species cover, and production values are representative. These are not intended to cover the full range of conditions, species, and responses for the site. Cover values are presented as foliar cover unless otherwise noted. Species composition by dry weight is provided when describing the herbaceous plant communities.

State and transition model

Ecosystem states



T1A - prolonged drought, improper grazing, or a combination of these factors

T1B - introduction of aggressive perennial grasses (mostly Crested Wheatgrass)

T1C - conversion to annual cropland

R2A - range seeding, grazing land mechanical treatment, timely moisture, proper grazing management (management intensive and costly)

T2A - introduction of weedy species; combined with drought and/or improper grazing management

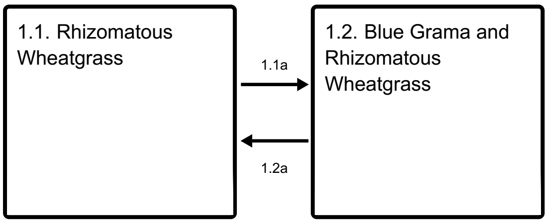
T2B - conversion to annual cropland

T3A - conversion to annual cropland

T4A - cessation of annual cropping

T5A - conversion to annual cropland

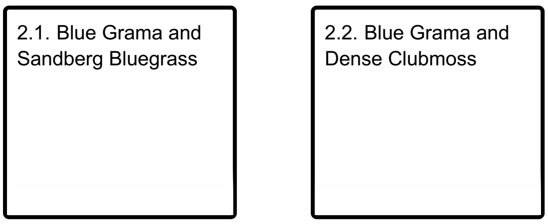
State 1 submodel, plant communities



1.1a - drought, improper grazing management, multiple fires in close succession

1.2a - timely moisture, proper grazing management

State 2 submodel, plant communities



State 3 submodel, plant communities

3.1. Blue Grama and Crested Wheatgrass

State 4 submodel, plant communities

4.1. Cropland Community

State 5 submodel, plant communities

5.1. Abandoned Cropland

5.2. Perennial Grass

State 1
Reference

The Reference State consists of two community phases. The dynamics of this state are driven by the combined influences of climate, grazing, and fire. Dense clubmoss may be present in any of the phases within this state; however, its density is highly variable and the dynamics of this species are not well understood. Research has shown that its density is affected by drought, fire, and hoof action by grazing animals (Coupland 1950, VanDyne and Vogel 1967, Clarke et al. 1947). However, its abundance may vary greatly from site to site without discernable reason. In general, this state is characterized by a predominance of mid-statured, cool season rhizomatous grasses. As ecological conditions decline; mid-statured grasses decrease and are replaced by short-statured grasses such as blue grama and Sandberg bluegrass. Plant Community 1.2 is dominated by blue grama and rhizomatous wheatgrasses, although wheatgrasses decrease in this community. Sandberg bluegrass also increases in Plant Community 1.2, as does prairie sagewort. Drought, improper grazing management, or a combination of these factors can transition this state to the Shortgrass State (2).

Dominant plant species

- western wheatgrass (*Pascopyrum smithii*), grass

Community 1.1
Rhizomatous Wheatgrass

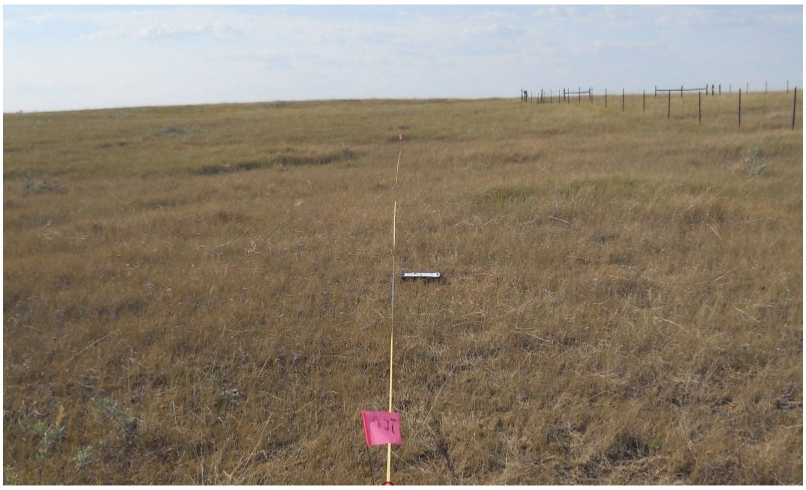


Figure 7. Figure 7 Rhizomatous Wheatgrass plant community (1.1) for Thin Claypan Dry Grassland ecological site. Elloam Soils. Photo by Montana Natural Heritage Program, Valley County, Montana, August 2012

This plant community is dominated by rhizomatous wheatgrasses. Both western wheatgrass and thickspike wheatgrass can occur in this community, although western wheatgrass is more common due to its greater tolerance of droughty conditions associated with this site (Coupland 1950). Short-statured, cool-season grasses, particularly prairie Junegrass and Sandberg bluegrass, are common on these sites although cover and production are low. The mat-forming, warm-season perennial grass, blue grama is also an important component of this site, although its contribution varies with climate and disturbance. Due to the impermeable nature of the soil, deeper-rooted bunchgrasses such as needle and thread are not well-adapted to this site (Coupland 1961), although needle and thread can occur as a minor component of the plant community on portions of the site with thicker soil horizons. Both the species composition and cover of forbs are typically low on this site, generally five percent cover or less. Common forb species include spiny, or Hood's, phlox (*Phlox hoodii*) and scarlet globemallow (*Sphaeralcea coccinea*). Dense clubmoss cover varies substantially, with some sites having 70 to 80 percent cover and other sites having little or no cover. The subshrub prairie sagewort is common but with low cover. Plains pricklypear is uncommon. The principal shrub on this site, if present, is silver sagebrush, although canopy cover is generally less than five percent. Non-native annual bromes, particularly field brome, have become naturalized on this ecological site. Cover of annual bromes is typically low, but it can vary significantly from season to season depending on seed germination conditions. Frequent fires can reduce litter accumulation enough to limit field brome germination (Whisenant 1990). However, long-term fire suppression may result in increased litter accumulation and greater germination of non-native annual bromes.   The following tables characterize the Rhizomatous Wheatgrasses Plant Community (1.1) by the following elements: Plant Community Phase Composition and Foliar Cover Total Annual Production Ground Surface Cover Structure Information in these tables was developed using current field data in conjunction with a review of the scientific literature and professional experience.

Dominant plant species

- western wheatgrass (*Pascopyrum smithii*), grass

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	220	395	625
Forb	40	70	115
Shrub/Vine	10	15	20
Total	**270**	**480**	**760**

Table 8. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0-5%
Grass/grasslike foliar cover	50-70%

Forb foliar cover	1-30%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	20-50%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 9. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	1-5%
Forb basal cover	0-80%
Non-vascular plants	0-10%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	5-25%	1-10%
>0.5 <= 1	–	0-1%	25-55%	–
>1 <= 2	–	0-5%	5-10%	–
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 9. Plant community growth curve (percent production by month). MT005, MLRA 52 (cool season dominant). Typically occurs in Reference or Contemporary Reference State.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			10	25	45	15	5				

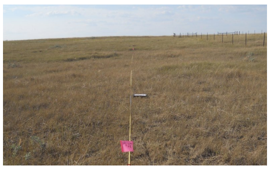
Community 1.2

Blue Grama and Rhizomatous Wheatgrass

Figure 10. Figure 3. Blue Grama and Rhizomatous Wheatgrass Plant (1.2) Community for Thin Claypan Dry Grassland ecological site. Elloam Soils. Photo by Charles French (Soil Scientist, NRCS), Phillips County, Montana, June 2015

Drought, improper grazing management, multiple fires in close succession, or a combination of these factors can shift the Rhizomatous Wheatgrass Plant Community (1.1) towards the Blue Grama and Rhizomatous Wheatgrass Plant Community (1.2). This community phase is characterized by an increase in the warm-season, mat-forming blue grama. The cover of blue grama equals or exceeds wheatgrasses, which decreases in this community. The cool-season, perennial bunchgrass needle and thread becomes rare or is absent. The shortgrass, Sandberg bluegrass and the subshrub, prairie sagewort, increase in this phase. This plant community is considerably less productive than the Rhizomatous Wheatgrass Plant Community due to the significant decrease in cool-season rhizomatous wheatgrasses. This plant community can return to the rhizomatous wheatgrass plant community with proper grazing management and normal or above-normal spring precipitation. Continued improper grazing management will drive this community to the Shortgrass State (2).

Pathway 1.1a
Community 1.1 to 1.2



Rhizomatous Wheatgrass

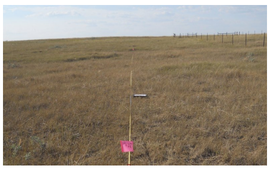
Blue Grama and Rhizomatous Wheatgrass

Drought, improper grazing management, multiple fires in close succession, or a combination of these factors can shift the Rhizomatous Wheatgrass Plant Community (1.1) to the Blue Grama and Rhizomatous Wheatgrass (1.2). These factors favor an increase in blue grama and a decrease in cool-season midgrasses (Coupland 1961, Shay et al. 2001).

Context dependence. Timing of precipitation may affect species composition of perennial grasses.

Pathway 1.2a
Community 1.2 to 1.1

Blue Grama and Rhizomatous Wheatgrass



Rhizomatous Wheatgrass

The Blue Grama and Rhizomatous Wheatgrass plant community (1.2) can return to the Rhizomatous Wheatgrass

Plant Community (1.1) with normal or above-normal spring precipitation and proper grazing management.

Context dependence. Timing of precipitation may affect species composition of perennial grasses.

State 2
Shortgrass

The Shortgrass State consists of two community phases. The dynamics of this state are driven by long-term drought, improper grazing management, or a combination of these factors. Rhizomatous wheatgrasses have low production and poor vigor in this state. Prairie sagewort is common. Blue grama increases with long-term improper grazing at the expense of cool-season midgrasses (Coupland 1961, Biondini and Manske 1996, Derner and Whitman 2009). Reductions in stocking rates can reduce blue grama cover and increase the cover of cool-season midgrasses, although this recovery may take decades (Dormaar and Willms 1990, Dormaar et al. 1994). Dense clubmoss may or may not be present in this state and the dynamics of this species are not well understood. In some cases it is abundant on heavily grazed areas, but in others it is rare or absent. Its abundance varies greatly from site to site without discernable reason, therefore, it is not considered a reliable indicator of past grazing use (Montana State College 1949). Annual bromes are also present in this state. They are naturalized but usually do not have a significant ecological impact; however, their abundance varies depending on precipitation and germination conditions.

Community 2.1
Blue Grama and Sandberg Bluegrass

On sites where clubmoss is not present, the Blue Grama and Sandberg Bluegrass Plant Community occurs as the result of long-term improper grazing management. This plant community is dominated by the warm season, mat-forming blue grama and cool-season shortgrasses, particularly Sandberg bluegrass. Long-term improper grazing management has considerably reduced the cover and annual production of this site, changing the structure of this plant community from a mid-statured grassland to a shortgrass community (Derner and Hart 2007). Cool season, rhizomatous wheatgrasses have decreased significantly in this phase, and grazing tolerant species like blue grama, Sandberg bluegrass, and prairie Junegrass have increased. Prairie sagewort also increases in this phase.

Figure 11. Plant community growth curve (percent production by month). MT041, MLRA 52 (warm season dominant). Typically occurs in the Short Grass State.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			5	20	50	20	5				

Community 2.2
Blue Grama and Dense Clubmoss

On sites where clubmoss is present, the Blue Grama and Dense Clubmoss Plant Community occurs as the result of long-term improper grazing management. The cool-season rhizomatous wheatgrasses are rare and have low reproductive vigor. The warm-season, mat-forming blue grama and dense clubmoss comprise the dominant basal cover for this phase. Prairie sagewort, Sandberg bluegrass, and prairie Junegrass are also common. Continued improper grazing management combined with the introduction of invasive pasture grasses can drive this community phase to the Invaded State (3).

State 3
Invaded

The Invaded State (3) occurs when invasive plant species, primarily crested wheatgrass, invade adjacent native grassland communities. An estimated 20 million acres of crested wheatgrass have been planted in the western U.S. (Holechek 1981). Since the 1930s, crested wheatgrass has been planted to improve forage for livestock (Roglers and Lorenz 1983, Laycock 1988). Beginning in the mid-1980s, crested wheatgrass was often seeded on lands enrolled in the Conservation Reserve Program (CRP; Roath 1988, DeLuca and Lesica 1996). Crested wheatgrass is extremely drought tolerant, establishes readily on a variety of soil types, has high seedling vigor, and provides highly productive early season forage for livestock (Rogler and Lorenz 1983). Once established, monocultures of crested wheatgrass can persist for at least 60 years (Krzic et al. 2000, Henderson and Naeth 2005), as crested wheatgrass stands resist recruitment of native plant species (Looman and Heinrichs 1973, Henderson and Naeth 2005, Fansler and Mangold 2011). Crested wheatgrass produces abundant seeds that can dominate the seedbank of invaded grasslands, although crested wheatgrass cover decreases with increasing distance from seeded areas (Henderson and Naeth 2005, Heidinga and Wilson 2002). The early growth of crested wheatgrass allows this species to take advantage of early season soil moisture, which may result in competitive exclusion of native cool-season rhizomatous wheatgrasses and bunchgrasses such as needle and thread and prairie Junegrass (Christian and Wilson 1999, Heidinga and Wilson 2002, Henderson and Naeth 2005). If already established, the warm-season, mat-forming blue grama may compete successfully with crested wheatgrass, although the ability of blue grama to persist in invaded stands is unknown due to its low seed production and narrow germination requirements (Coupland 1950, Heidinga and Wilson 2002, Lauenroth et al. 1994). Reduced soil quality, reduced plant species diversity, and simplified structural complexity (Dormaar et al. 1995, Henderson and Naeth 2005) result in a state that is substantially departed from the Reference State (1).

Community 3.1
Blue Grama and Crested Wheatgrass

Encroachment by Crested Wheatgrass and other invasives common. Rangeland health attributes departed substantially from reference state

State 4
Annual Cropland

The Annual Cropland State (4) occurs when land is put into cultivation. Major crops in MLRA 52 include winter and spring wheat, as well as barley.

Community 4.1
Cropland Community

Annual, cool-season cereal grains such as spring wheat, winter wheat, and barley are common crops which replace native plant communities.

State 5
Post-Cropland

The Post-Cropland State (5) occurs when cultivated cropland is abandoned and allowed to either re-vegetate naturally or is seeded back to perennial species for livestock grazing or wildlife use. This state can transition back to the Cropland State (4) if the site is returned to cultivation.

Community 5.1
Abandoned Cropland

In the absence of active management, the site can re-vegetate naturally and potentially return to a perennial grassland community over time. Shortly after cropland is abandoned, annual and biennial forbs and annual brome grasses invade the site. The site is highly 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, mid-statured perennial grasses may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species, such as crested wheatgrass and annual bromes, 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 Reference State (1). However, soil quality is consistently lower than conditions prior to cultivation and a shift to the Reference State (1) is unlikely within a reasonable timeframe (Dormaar, J.F., and S. Smoliak. 1985).

Community 5.2
Perennial Grass

When the site is seeded to perennial forage species this community phase can persist for several decades.

Introduced perennial grasses, in particular, may form monocultures that persist for 60 years or more (Samuel, M.J., and R.H. Hart. 1994). A mixture of native species may also be seeded to provide species composition and structural complexity similar to that of the Reference State (1). However, soil quality conditions have been substantially altered and will not return to pre-cultivation conditions within a reasonable timeframe.

Transition T1A
State 1 to 2

The Reference State (1) transitions to the Shortgrass State (2) when cool-season rhizomatous wheatgrasses become rare and contribute little to production. Shortgrasses, particularly the warm-season, mat-forming blue grama, as well as Sandberg bluegrass, dominate the plant community. Prolonged drought, improper grazing practices or a combination of these factors weaken the resilience of the Reference State (1) and drive its transition to the Shortgrass State (2).

Context dependence. Drought may accelerate or exacerbate change. Soils are particularly susceptible to erosion when dry.

Transition T1B
State 1 to 3

The Reference State (1) transitions to the Invaded State (3) when aggressive perennial grasses, particularly crested wheatgrass, invade the Reference State (1). These communities are often adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced and other rangeland health attributes such as reproductive capacity of native grasses and soil quality have been substantially altered from the Reference State (Henderson and Naeth 2005, Smoliak and Dormaar 1985, Dormaar et al. 1995).

Context dependence. Close proximity to a seed source increases likelihood of encroachment by invasive species.

Transition T1C
State 1 to 4

The Reference State (1) will transition to the Cropland State (4) when the site is placed into cultivation with crops such as winter and spring wheat and barley.

Context dependence. Drought may accelerate or exacerbate change. Cropped soils are particularly susceptible to erosion during drought.

Restoration pathway R2A
State 2 to 1

Blue grama can resist displacement by other species (Dormaar and Willms 1990, Laycock 1991, Dormaar et al. 1994, Lacey et al. 1995). A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of blue grama in the Shortgrass State (2) (Dormaar and Willms 1990), and mechanical treatments may be necessary (Hart et al. 1985). Therefore, returning the Shortgrass State (2) to the Reference State (1) can require considerable cost, energy, and time.

Context dependence. Drought may inhibit recovery despite management inputs. Reseedings are more likely to fail during drought.

Transition T2A
State 2 to 3

The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses, particularly crested wheatgrass, invade the Shortgrass State (2). This transition can occur when native plant communities are adjacent to seeded pastures. Exotic plant species, particularly crested wheatgrass, dominate the site in terms of cover and production. Crested wheatgrass can outcompete native grasses (Vaness and Wilson 2007), weakening site resilience and impacting rangeland health attributes such as the reproductive capacity of native grasses

(Henderson and Naeth 2005) and soil quality (Smoliak and Dormaar 1985, Dormaar et al. 1995).

Context dependence. Close proximity to a seed source increases likelihood of encroachment by invasive species.

Transition T2B
State 2 to 4

The Shortgrass State (2) transitions to the Cropland State (4) when the site is placed into cultivation with crops such as winter and spring wheat and barley.

Context dependence. Drought may accelerate or exacerbate change. Cropped soils are particularly susceptible to erosion during drought.

Transition T3A
State 3 to 4

The transition from the Invaded State (3) to the Annual Cropland State (4) occurs when the site is placed into cultivation with crops such as winter and spring wheat and barley.

Context dependence. Drought may accelerate or exacerbate change. Cropped soils are particularly susceptible to erosion during drought.

Transition T4A
State 4 to 5

The transition from the Annual Cropland State (4) to the Post-Cropland State (5) occurs with the cessation of cultivation. The site may also be seeded to perennial forage species such as crested wheatgrass and alfalfa or a mix of native species.

Context dependence. Drought may inhibit recovery despite management inputs. Reseedings are more likely to fail during drought.

Transition T5A
State 5 to 4

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

Context dependence. Drought may accelerate or exacerbate change. Cropped soils are particularly susceptible to erosion during drought.

Additional community tables

Table 11. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid stature, cool season rhizomatous grasses**			155–430	
	western wheatgrass	PASM	*Pascopyrum smithii*	125–340	21–65
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	125–340	21–65
	plains reedgrass	CAMO	*Calamagrostis montanensis*	30–90	4–8
2	**Mid stature, cool season bunchgrasses**			0–40	
	needle and thread	HECO26	*Hesperostipa comata*	0–40	0–5
3	**Short stature graminoids**			40–115	
	blue grama	BOGR2	*Bouteloua gracilis*	20–50	2–10
	prairie Junegrass	KOMA	*Koeleria macrantha*	15–45	1–5
	sedge	CAREX	*Carex*	15–40	1–5
	Sandberg bluegrass	POSE	*Poa secunda*	0–10	0–5
4	**Other Native Graminoids**			15–40	
	Grass, perennial	2GP	*Grass, perennial*	15–40	1–5
Forb					
5	**Perennial forbs**			40–115	
	Forb, native	2FN	*Forb, native*	20–40	1–5
	common yarrow	ACMI2	*Achillea millefolium*	15–30	1–10
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	5–15	0–2
	American vetch	VIAM	*Vicia americana*	0–15	0–2
	pussytoes	ANTEN	*Antennaria*	5–10	0–2
	spiny phlox	PHHO	*Phlox hoodii*	0–5	0–1
	rough false pennyroyal	HEHI	*Hedeoma hispida*	0–5	0–1
Shrub/Vine					
6	**Native Shrubs and Halfshrubs**			8–15	
	silver sagebrush	ARCA13	*Artemisia cana*	0–15	0–5
	prairie sagewort	ARFR4	*Artemisia frigida*	8–15	0–1
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0–5	0–1
7	**Cactus**			2–5	
	plains pricklypear	OPPO	*Opuntia polyacantha*	2–5	1–2

Animal community

Grassland communities within the Thin Claypan ecological site of MLRA 52C support a diverse animal community. Grasshopper species can significantly impact plant production during outbreaks or periods of drought, competing with other grazers on this site (Branson and Sword 2010). Grasshopper density and species richness can increase with changes in vegetation structure and composition associated with disturbances such as fire and grazing (Joern 2005).

Although amphibians use wetlands throughout MLRA 52 for breeding, most amphibian species, including boreal chorus frog (Pseudacris maculata), western tiger salamander (Ambystoma mavortium), and plains spadefoot (Spea bombifrons), rely on the surrounding grasslands for survival during the non-breeding season (Semlitsch 2000, Mushet et al. 2012). Similarly, several reptile species including, prairie rattlesnake (Crotalus viridis), gophersnake (Pituophis catenifer), and plains gartersnake (Thamnophis radix) occur throughout grassland communities.

A variety of migratory grassland birds breed throughout this ecological site. Eight bird species that are endemic or restricted to the Northern Great Plains breed in MLRA 52 (Knopf 1996). The composition of grassland birds varies with vegetation structure, and the species composition of the breeding bird community will vary depending upon the state and/or community phase occurring on the site (Madden et al. 2000, Henderson and Davis 2014). For example, species such as Sprague's pipit (Anthus spragueii) and Baird's sparrow (Ammodramus bairdii) are more abundant in native, mixed-grass communities associated with the Contemporary Reference State (Madden et al. 2000, Davis et al. 2013). Similarly, species such as McCown's longspur (Rhynchophanes mccownii) primarily occur in plant communities dominated by shortgrasses (With 2010). Most endemic grassland songbirds have reduced abundance and nesting success in grasslands that have been planted with non-native, perennial grasses, analogous to the Pasture/CRP community phase (6.2) of the Post-Cropland State (6) (Davis et al. 2013). Other bird species such as long-billed curlew (Numenius americanus) and greater sage grouse (Centrocercus urophasianus) rely on a variety of habitats for nesting and brood-rearing, emphasizing the importance of managing for diverse vegetation structure (Derner et al. 2009).

Upland nesting waterfowl species, including lesser scaup (Aythya affinis), mallard (Anas platyrhynchos), gadwall (Anas strepera), American wigeon (Anas americana), Eurasian teal (Anas crecca), Blue-winged teal (Anas discors), and northern pintail (Anas acuta) require extensive grasslands represented by this ecological site for nesting and brood-rearing (Stephens et al. 2005). Additionally, several raptor species including, northern harrier (Circus cyaneus), Swainson's hawk (Buteo swainsoni), and ferruginous hawk (Buteo regalis), as well as the short-eared owl (Asio flammeus) breed in these plant communities.

Rodents such as Richardson's ground squirrel (Urocitellus richardsonii) and black-tailed prairie dog (Cynomys ludovicianus) play an important role in plant species composition and production through the excavation of soils to create burrows (Bylo et al. 2014). Historically, native ungulate grazers, in conjunction with fire and drought, played an important ecological role in shaping the composition and structure of the plant communities on this site. Historic grazers included bison (Bison bison), elk (Cervus elaphus), deer (Odocoileus spp.), and pronghorn (Antilocapra americana) (Knopf and Samson 1997). Cattle have largely replaced these species as the dominant grazer of this site.

Hydrological functions

The primary limitation to infiltration on this site is soil structure. While infiltration is generally high in the surface horizon, the underlying natric horizon one to four inches below the surface severely restricts infiltration and root growth, thus favoring the shallow-rooted rhizomatous grasses. While soil erosion is typically minimal, during heavy precipitation events, water may run off the site if it is in a micro high position or conversely onto the site if it is in a micro low position.

Recreational uses

This ecological site offers fair to good opportunities for nature observation, photography, and hunting.

Wood products

This ecological site has little to no potential for wood products.

Other products

This ecological site is suitable for grazing by cattle. Due to the hardpan nature of these soils, this ecological site is not well suited for cropland. However, despite the soil limitations and relatively low crop yields this site has been broken and managed as cropland in places.

Other information

For plant preferences by animal kind refer to: Field Office Technical Guide, Section II, Ecological Site Descriptions, General Information.

Inventory data references

A minimum of 20 low or medium observations are required to meet verification level status. This ESD is citing National Resources Inventory (NRI) and 417 data to meet these minimums. Individual observations are listed in EDIT and are viewable behind the login. A corresponding tracking sheet is available in the MLRA office that links the list to the actual observations used in analysis. A total of 29 plots ranging from low to high intensity were used as a basis for this ecological site. Plant community data are based primarily on high intensity data collected at five plots representing the Rhizomatous Wheatgrass Plant Community (1.1). Vegetation data collection protocols followed (Herrick et al. 2009).

Other references

References cited in this ecological site description include:

Adams, B. W., J. Richman, L. Poulin-Klein, K. France, D. Moisey, and R. L. McNeil. 2013. Rangeland plant communities for the dry mixedgrass natural subregion of Alberta. Second approximation. Rangeland management branch, policy division, Alberta Environment and Sustainable Resource Development, Lethbridge, Pub. No. T/040 135pp.

Anderson, R. C. 2006. Evolution and origin of the central grassland of North America: climate, fire, and mammalian grazers. 133:626-647.

Baskin, J. M., and C. C. Baskin. 1981. Ecology of germination and flowering in the weedy winter annual grass Bromus japonicus. Journal of Range Management 34:369-372.

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: Joern, A., Keeler, K.H. (Eds.), The Changing Prairie. Oxford University Press, Oxford, pp. 49–81.

Branson, D. H., and G. A. Sword. 2010. An experimental analysis of grasshopper community responses to fire and livestock grazing in a northern mixed-grass prairie. Environmental Entomology. 39:1441-1446.

Bylo, L. N., N. Koper, and K. A. Molloy. 2014. Grazing intensity influences ground squirrel and American badger habitat use in mixed-grass prairies. Rangeland Ecology and Management 67:247-254.

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.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G., King, T.; Russell, W.E. 1997. National Hierarchical Framework of Ecological Units. Published in, Boyce, M. S.; Haney, A., ed. 1997. Ecosystem Management Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, CT.

Cooper, S. V., C. Jean, and P. Hendricks. 2001. Biological survey of a prairie landscape in Montana's glaciated plains. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena. 24 pp. plus appendices.

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. The Journal of Ecology 53:475-507.

Davis, S. K., R. J. Fisher, S. L. Skinner, T. L. Shaffer, and R. M. Brigham. 2013. Songbird abundance in native and planted grassland varies with type and amount of grassland in the surrounding landscape. The Journal of Wildlife Management 77:908-919.

DeLuca, T. H., and P. Lesica. 1996. Long-term harmful effects of crested wheatgrass on Great Plains grassland ecosystems. Journal of Soil and Water Conservation 51: 408-409.

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.

Derner, J. D., and A. J. Whitman. 2009. Plant interspaces resulting from contrasting grazing management in northern mixed-grass prairie: implications for ecosystem function. Rangeland Ecology and Management 62:83-88.

Derner, J. D., W. K. Lauenroth, P. Stapp, and D. J. Augustine. 2009. Livestock as ecosystem engineers for grassland bird habitat in the western Great Plains of North America. Rangeland Ecology and Management 62:111-118.

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., 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.

Fansler, V. A., and J. M. Mangold. 2010. Restoring native plants to crested wheatgrass stands. Restoration Ecology 19:16-23.

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.

Fullerton, D.S., R.B. Colton, and C.A. Bush. 2013, Quaternary geologic map of the Shelby 1° x 2° quadrangle, Montana: U.S. Geological Survey Open-File Report 2012–1170, scale 1:250,000

Haferkamp, M. R., R. K. Heitschmidt, and M. G. Karl. 1997. Influence of Japanese brome on western wheatgrass yield. Journal of Range Management 50:44-50.

Harmoney, K. R. 2007. Grazing and burning Japanese brome (Bromus japonicus) on mixed grass rangelands. Rangeland Ecology and Management 60:479-486.

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, Montana. 96 p.

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, A. E., and S. K. Davis. 2014. Rangeland health assessment: a useful tool for linking range management and grassland bird conservation? Rangeland Ecology and Management 67:88-98.

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. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish and Wildlife Service Resource Publication 161, Washington, DC.

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

Joern, A. 2005. Disturbance by fire frequency and bison grazing modulate grasshopper assemblages in tallgrass prairie. Ecology 86:861-873.

Knopf, F. L. 1996. Prairie legacies-birds. Pp. 135-148. In: F. B. Samson and F. L. Knopf (eds.) Prairie conservation: preserving North America's most endangered ecosystem. Island Press, Washington, DC.

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

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.

Lauenroth, W. K., O. E. Sala, D. P. Coffin, and T. B. Kirchner. 1994. The importance of soil water in recruitment of Bouteloua gracilis in the shortgrass steppe. Ecological Applications 4:741-749.

Laycock, W. A. 1988. History of grassland plowing and grass planting on the Great Plains. In: J. E. Mitchell (ed.) Impacts of the Conservation Reserve Program in the Great Plains: symposium proceedings, September 16-18, 1987. USDA, General Technical Report RM-158. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

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.

Looman, J., and D. H. Heinrichs. 1973. Stability of crested wheatgrass pastures under long-term pasture use. Canadian Journal of Plant Science 53:501-506.

Madden, E. M., R. K. Murphy, A. J. Hansen, and L. Murray. 2000. Models for guiding management of prairie bird habitat in northwestern North Dakota. The American Midland Naturalist 144:377-392.

McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech. Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

Miller, J. J. and J. A. Brierley. 2011. Solonetzic soils of Canada: genesis, distribution, and classification. Canadian Journal of Soil Science 91:889-902.

Montana State College. 1949. Similar Vegetative Rangeland Types in Montana. Montana State College, Agri. Exp. Station. 35 p.

Mushet, D. M., N. H. Euliss, Jr., and C. A. Stockwell. 2012. A conceptual model to facilitate amphibian conservation in the Northern Great Plains. Great Plains Research 22:45-58.

Nesser, John A.; Ford, Gary L.; Maynard, C. Lee; Page-Dumroese, Deborah S. 1997. Ecological units of the Northern Region: Subsections. Gen. Tech. Rep. INT-GTR-369. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 88 p.

Oard, M. J. A method of predicting Chinook winds east of the Montana Rockies. 1993. Weather and Forecasting 8:166-180

Ogle, D., L. St. John, J. Cornwell, L. Holzworth, M. Majerus, D. Tober K. Jensen, K. Sanders Ed. (rev) St. John, 2012. Plant guide for Russian wildrye (Psathyrostachys junceus). USDA-Natural Resources Conservation Service, Aberdeen Plant Materials Center. Aberdeen, Idaho 83210.

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.

Roath, L. R. 1988. Implications of land conversions and management for the future. In: J. E. Mitchell (ed.) Impacts of the Conservation Reserve Program in the Great Plains: symposium proceedings, September 16-18, 1987. USDA, General Technical Report RM-158. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

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.

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

Salo, E. D., K. F. Higgins, B. D. Patton, K. K. Bakker, W. T. Barker, B. Kreft, and P. E. Nyren. 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, Wisconsin.

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.

Semlitsch, R. D. 2000. Principles for management of aquatic-breeding amphibians. The Journal of Wildlife Management 64:615-631.

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.

Smith, R. E. 2013. Conserving Montana’s sagebrush highway: long distance migration in sage-grouse. M.S. Thesis. University of Montana, Missoula.

Smoliak, S., J. F. Dormaar, and A. Johnston. 1972. Journal of Range Management 25:246-250.

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., and J. F. Dormaar. 1985. Productivity of Russian wildrye and crested wheatgrass and their effect on prairie soils. Journal of Range Management 38:403-405.

Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC.

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

Stephens, S. E., J. J. Rotella, M. S. Lindberg, M. L. Taper, and J. K. Ringelman. 2005. Duck nest survival in the Missouri Coteau of North Dakota: landscape effects at multiple spatial scales. Ecological Applications 15:2137-2149.

Umbanhowar, Jr., C. E. 2004. Interactions of climate and fire at two sites in the Northern Great Plains. Palaeogeography, Palaeoclimatology, and Palaeoecology 208:141-152.

U.S. Fish and Wildlife Service. 2013. Greater sage-grouse (Centrocercus urophasianus) conservation objectives: Final Report. U.S. Fish and Wildlife Service.

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.

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.

With, K. A. 2010. McCown's Longspur (Rhynchophanes mccownii), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/09

Contributors

Karen Newlon
Scott Brady
Stuart Veith

Approval

Marji Patz, 2/12/2025

Acknowledgments

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

Field Data Collection
Montana Natural Heritage Program (MTNHP)

GIS Products, Data Summaries, Contract Liaison
Cathy Maynard, USDA-NRCS

Background Research and Literature Review
Karen Newlon, formerly MTNHP
Scott Brady, USDA-NRCS

Soil Concepts, Soils Information, and Field Descriptions
Charlie French, USDA-NRCS (retired)
Stuart Veith, USDA-NRCS
Josh Sorlie, USDI-BLM
Jack Robertson, formerly USDA-NRCS

NASIS Reports, Data Exports, and Soil Sorts
Bill Drummond, USDA-NRCS (retired)

Peer Review and Beta Testing
Kirt Walstad, USDA-NRCS
Jon Siddoway, USDA-NRCS (retired)
Rick Caquelin, USDA-NRCS
Malta Field Office, USDI-BLM
Havre Field Office, USDI-BLM

Quality Control
Kirt Walstad, USDA-NRCS

Quality Assurance
Stacey Clark, USDA-NRCS

Preceding Version(s):
Claypan 10 to 14 inch p.z. R052XC204MT (Lacey et al., 2005)
Claypan 10 to 14 inch p.z. R052XN204MT (Lacey et al., 2005)

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	Grant Petersen
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:**
