USDA Natural Resources Conservation Service

Ecological site R046XN628MT
Claypan (Cp) RRU 46-N 13-19 PZ

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General information

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

MLRA notes

Major Land Resource Area (MLRA): 046X–Northern and Central Rocky Mountain Foothills

Major Land Resource Area (MLRA) 46, Rocky Mountain Foothills, is approximately 11.6 million acres. MLRA 46's extent has changed over recent years and is now primarily located in Montana and Wyoming with limited acres in Utah and Colorado. It spans from the Canadian border south to the Uinta Mountains of Northwest Colorado. MLRA 46 is a transitional MLRA between the plains and mountains of primarily non-forested rangeland. In Montana, 3 Land Resource Units (LRUs) exist based on differences in geology, landscape, soils, water resources, and plant communities. Elevations for this MLRA in Montana vary from a low of 3200 feet to 6500 feet (975-1981m) however the elevations on the fringes of this MLRA may fall outside of that range in extremely small isolated areas where the boundaries between neighboring MLRAs are not easily defined. Annual precipitation ranges from 8 inches (254 mm) to, in very isolated areas, 42 inches (1083 mm). In general precipitation rarely exceeds 24 inches (610 mm). Frost-free days are variable from 50 days near the Crazy and Beartooth Mountains to 130 days in the foothills south of the Bear's Paw Mountains of Central Montana. The geology of MLRA 46 is generally Cretaceous and Jurassic marine sediments.

MLRA 46's plant communities are dominated by cool-season bunchgrasses with mixed shrubs. This MLRA is rarely forested; however, ponderosa and limber pine do occupy areas. Portions of this MRLA may have a sub dominance of warm-season mid-statured bunchgrasses like little bluestem; however, the general concept of the MLRA does not have a large component of warm-season species. Wyoming big sagebrush, mountain big sagebrush, silver sagebrush, common snowberry, and shrubby cinquefoil tend to be the dominant shrub component. The kind and presences of shrubs tends to be driven by a combination of soils and climate. Due to the variable nature of the Land Resources Units, Climatic subsets will be necessary to describe the ecological sites and the variation of plant communities for this MLRA.

LRU notes

The Rocky Mountain Front Foothills LRU is the northernmost LRU of MLRA 46. The boundaries are the Canadian border to the north, MRLA 43B and the western extent of Continental Glaciation (MLRA 52). Boundaries between these MLRAs are extremely broad and often hard to distinguish.

Major watersheds of this LRU include the Missouri River, Sun River, Teton River, Marias River, and the Milk River. All of these river systems have been modified for the purpose of irrigation of pasture and crops.

The Rocky Mountain Front Foothills LRU's geology is generally sedimentary in nature. Primary geological units include Two Medicine Limestone and Sandstone, Colorado Shale, Glacial Drift (alluvium), Terrace deposits (alluvium) and St Mary River formation (mudstone). Landforms include outwash terraces, escarpments, fan remnants, valleys, hillslopes, and drainage ways. Elevations of this landscape is from 3221 feet (982m) to 6954 feet (2120m).
Well drained soils are dominate in this LRU. Most areas vary from nearly level to 15 percent slope, while some areas do express steeper slopes near the 43B boundary. Soils are Slight to Moderate Alkaline. Soil mean clay

percentages are mostly above 23 percent and are primarily very deep at approximately 70 percent of the LRU and moderately-deep to deep soils at approximately 30 percent of the LRU.

The climate of this LRU is highly variable however the average of 16.9 inches (429 mm) follows the typical MLRA concept. The major difference between this LRU and the others of MLRA 46 is the Chinook wind. These winds create massive temperature swings in the winter which can melt snow cover and initiate bud growth on shrubs. These changes may dry soil affecting plant production and species composition. The Rocky Mountain Front Foothills receives 10 inches (247 mm) to 42 inches (1083 mm) annually. However 42 inches is extremely limited extent. The average air temperature ranges from 36 degrees Fahrenheit (2.39 degrees C) to 46 degrees Fahrenheit (8.02 degrees C). The soil temperature regime is frigid with a soil moisture regime dominated by ustic with areas of udic. Average frost-free days is 70 to 110 days.

The vegetation potential for the Rocky Mountain Front Foothills LRU can be variable but is dominated by rangeland. Forested extents are typically minimal and consist primarily of Douglas-fir, limber pine, ponderosa pine, and Rocky Mountain juniper with mixed grassland understory. The rangeland of this LRU follows the general concept of the MLRA. The dryer sites are dominated by bluebunch wheatgrass and as the precipitation increases and temperatures decrease rough fescue increases. In areas that receive the highest precipitation, Columbia and Richardson’s needlegrass may exist. Shrub cover is limited in this area and is generally silver sagebrush and shrubby cinquefoil with areas of chokecherry and buffaloberry (both Russet and silver). The glacial drift areas will often have wetland associated vegetation in potholes as well as large areas of quaking aspen with mixed meadows.

Conversion from rangeland to cropland has been the largest land use change of this relatively intact grassland system. Small grain (barley and wheat) production is the most common crop produced in this area. Forage crops such as hay barley, perennial grass pasture, and alfalfa hay are also common. Irrigation from the area's extensive water resources facilitates highly productive farming practices.

MLRA 46 has experienced high conversion from rangeland to urban development where larger expanses of land have been separated into smaller ranchette subdivisions. Often these ranchettes experience extremely high grazing pressure from companion animals.

Classification relationships

EPA Ecoregion Level III: Canadian Rockies
Level IV: Northern Front
Southern Carbonate Front

EPA Ecoregion Level III: Northwestern Glaciated Plains
Level IV: Rocky Mountain Front Foothill Potholes
Sweetgrass Uplands
Foothills Grasslands
Glaciated Northern Grasslands

EPA Ecoregion Level III: Northwestern Great Plains
Level IV: Limy Foothill Grassland
Judith Basin Grassland

Ecological site concept

The distinguishing characteristic of this site is the presence of a dense, root-restricting, sodium-affected (natric) horizon at depths between 5 and 10 inches from the soil surface. The natric horizon exhibits columnar structure, is very hard, and severely limits both root penetration and infiltration. Soils are typically moderately deep to very deep (more than 20 inches to bedrock), are derived from till, and occur on slopes of less than 8 percent. Soil surface horizons (0 to 4 inches) are very fine sandy loam to loam, and the natric horizon is clay or clay loam. The root-restrictive natric horizon favors shallow-rooted rhizomatous species, particularly the rhizomatous wheatgrasses, over deep-rooted bunchgrasses. Other common grasses include plains reedgrass (Calamagrostis montanensis), blue grama (Bouteloua gracilis), Sandberg bluegrass (Poa secunda), and needle and thread (Hesperostipa comata).

Associated sites

R046XN252MT	**Silty (Si) RRU 46-N 13-19 PZ**

Similar sites

R046XN252MT	**Silty (Si) RRU 46-N 13-19 PZ**

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata* (2) *Krascheninnikovia lanata*
Herbaceous	(1) *Nassella viridula* (2) *Pseudoroegneria spicata*

Physiographic features

Claypan exists on the boundary of MLRAs 46 and 52 and the core concept belongs to MLRA 52. This ecological site largely occurs at higher elevations near the various mountain ranges and the Sweetgrass Hills. It mostly occurs on moraines (ground, recessional, or end) but can also occur on outwash fans or alluvial fans. In particular, it occurs on moraines underlain by the Bearpaw Shale Formation. The till incorporated physical and chemical properties of the underlying shale, which in the fringe of MLRAs 46 and 52 tend 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 and the gentler slopes of the till plain, water could pond and, by matric potential, 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 and Panspot ecological sites, complex micro-topography is typical on landforms dominated by natric soils. In relation to the Panspot and Thin Claypan ecological sites; the Claypan ecological site is found on microhighs, whereas when in complex with Loamy ecological sites it is found on microlows.

Table 2. Representative physiographic features

Landforms	(1) Foothills > Outwash plain (2) Foothills > Moraine
Elevation	3,600–4,590 ft
Slope	0–8%
Aspect	Aspect is not a significant factor

Climatic features

The climate of the Rocky Mountain Front LRU falls into Climatic Subset B. The central concept of Climatic Subset B is 13 to 19 inches Relative Effective Annual Precipitation (REAP) and 70 to 110 frost-free days. Calculated averages based on climate stations suggest, on average, that this Claypan ecological site receives just over 16 inches of precipitation with 72 to 116 frost-free days.

The soil temperature regime for this Claypan ecological site is frigid and the soil moisture regime is ustic

Table 3. Representative climatic features

Frost-free period (characteristic range)	63-87 days
Freeze-free period (characteristic range)	117-119 days
Precipitation total (characteristic range)	14-17 in
Frost-free period (actual range)	39-110 days
Freeze-free period (actual range)	70-123 days

Precipitation total (actual range)	12-19 in
Frost-free period (average)	72 days
Freeze-free period (average)	116 days
Precipitation total (average)	16 in

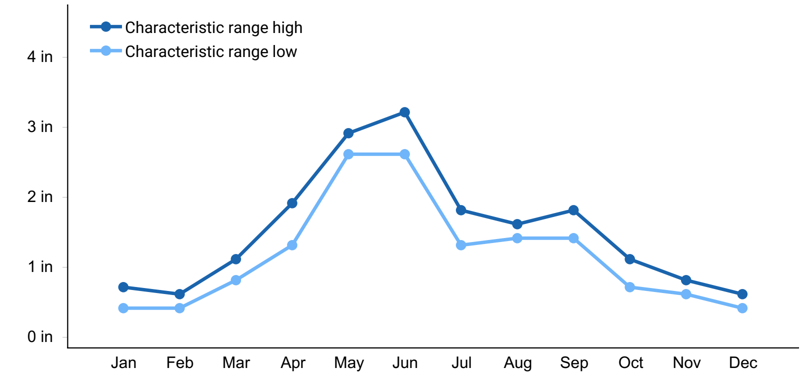

Figure 1. Monthly precipitation range

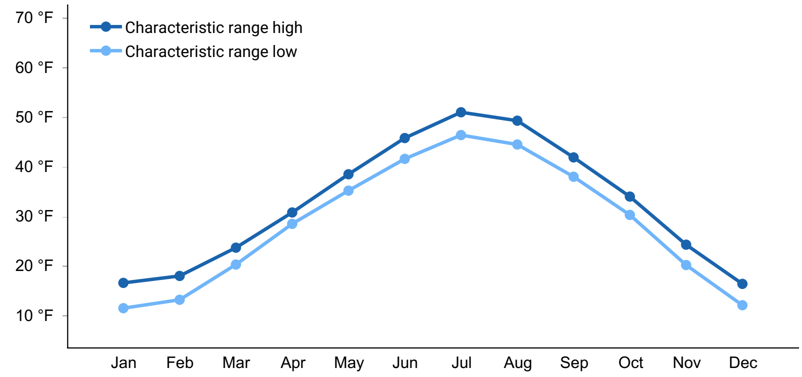

Figure 2. Monthly minimum temperature range

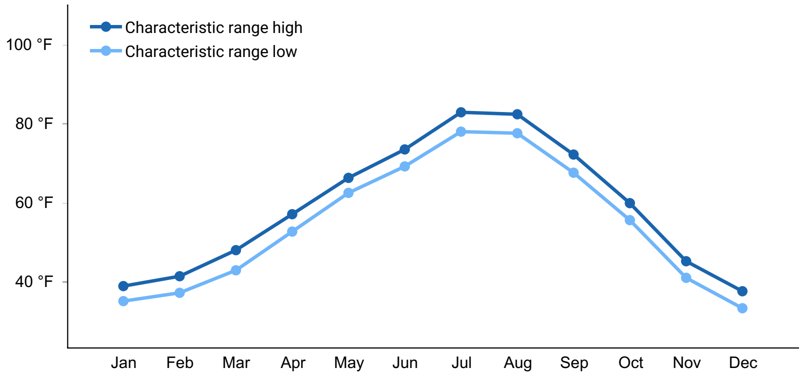

Figure 3. Monthly maximum temperature range

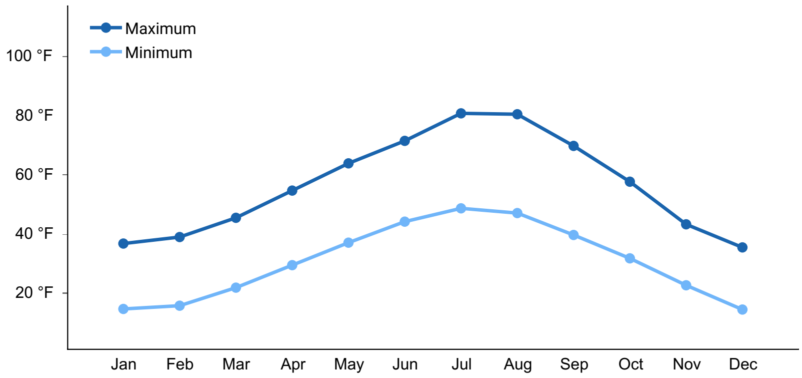

Figure 4. Monthly average minimum and maximum temperature

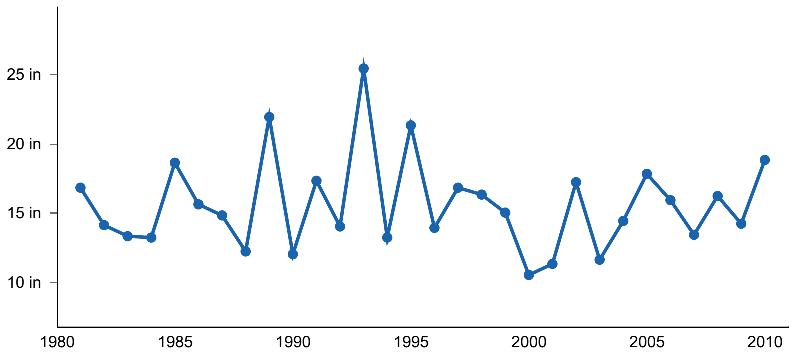

Figure 5. Annual precipitation pattern

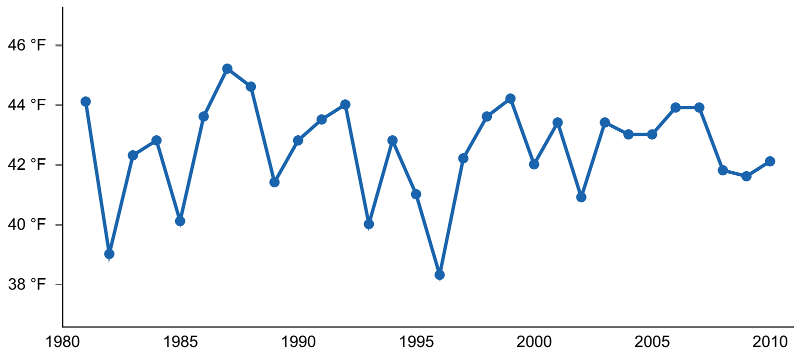

Figure 6. Annual average temperature pattern

Climate stations used

- (1) CUT BANK MUNI AP [USW00024137], Cut Bank, MT
- (2) AUGUSTA [USC00240364], Augusta, MT
- (3) CASCADE 5 S [USC00241552], Cascade, MT
- (4) BABB 6 NE [USC00240392], Babb, MT
- (5) GIBSON DAM [USC00243489], Augusta, MT
- (6) RAYNESFORD 2 NNW [USC00246902], Raynesford, MT

Influencing water features

This is a semi-arid, upland ecological site, but it has unique hydrology because infiltration is severely limited by the dense natric horizon 5 to 10 inches below the soil surface. Evapotranspiration exceeds precipitation on this site, and a moisture deficit state persists for the majority of the year. In typical precipitation events, the upper 5 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

The soil series that best represents the central concept of this ecological site is Weingart. This soil is in the Natrustolls great group. It has a relatively dark mollic epipedon and a dense, root-limiting, non-cemented restrictive layer 5 to 10 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 distinctive columnar structure that is especially visible when the soil is dry. The Weingart soil has smectitic minerology and is in the fine family, meaning that it could contain between 35 and 60 percent clay in the particle-size control section. The soil moisture regime for these and all soils in this ecological site concept is typic ustic, 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 horizon 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 45 percent clay and have clay, clay loam, or silty clay loam textures. Organic matter content in the surface horizon typically ranges from 2 to 5 percent, and moist colors vary from light gray (2.5YR 7/2) to dark grayish brown (2.5 YR 4/2). The surface of these soils does not typically react with hydrochloric acid. 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 2 and less than 8 and the sodium absorption ratio is typically less than 15. These salts lower the amount of plant available water. Soil pH is moderately acid 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 to 40 inches to bedrock) in places where bedrock is present but is typically very deep (more than 60 inches to bedrock). Content of coarse fragments is less than 35 percent in the upper 20 inches of soil and typically less than 15 percent.

Table 4. Representative soil features

Parent material	(1) Alluvium–sedimentary rock
Surface texture	(1) Clay (2) Clay loam (3) Silty clay loam
Family particle size	(1) Fine
Drainage class	Moderately well drained to well drained
Permeability class	Slow to moderate
Soil depth	20–100 in
Surface fragment cover <=3"	0–15%
Surface fragment cover >3"	0–2%
Available water capacity (0-40in)	4.5–6.3 in
Soil reaction (1:1 water) (0-10in)	6.1–7.8
Subsurface fragment volume <=3" (0-20in)	0–11%
Subsurface fragment volume >3" (0-20in)	0–2%

Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM) (Figure 2), 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 46 RRU 46-N consists of five states: The Reference State (1), the Shortgrass State (2), the Invaded State (3), the Cropland State (4), and the Post-Cropland State (5). 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).

Native grazers also shaped these plant communities. 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 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). Generally, the mixedgrass ecosystem is resilient to fire and the primary effects of the historic fire return interval are reduction of litter and short-term fluctuations in production (Vermeire et al., 2011, 2014). However, studies have shown that shorter fire return intervals can have a negative effect, shifting species composition toward warm-season, short-statured grasses (Shay et al., 2001; Smith and McDermid, 2014).

Improper grazing of this site can result in a reduction in the cover of the cool-season, midgrasses and an increase in blue grama (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 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 Sandberg bluegrass (Poa sandbergii). This site is also susceptible to invasion by non-native species. Non-native perennial bluegrasses (Poa spp.) are the most common invasive species. These species are widespread throughout the Northern Great Plains and appear able to invade any phase of the Reference State (1) (Toledo et al., 2014). Once established, they will displace native species and dominate the ecological functions of the site.

Due to the presence of a sodium-affected natric horizon, this ecological site is not generally regarded as productive cropland. Regardless, many acres have been cultivated and planted to 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 and Willms, 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) diagram (Figure 2) 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 1: Reference State
The Reference State (1) contains two community phases characterized by mid-statured rhizomatous wheatgrasses and mid-statured bunchgrasses, and shortgrasses such as blue grama. This state 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 and fire although these factors could influence species composition in localized areas. Lesser spikemoss, also known as dense clubmoss (*Selaginella densa*) is frequently present and may constitute significant ground cover. Its dynamics are not well understood, however, and its abundance varies greatly from site to site without discernable reason.

Phase 1.1: Mixedgrass Community Phase
The Mixedgrass Community Phase (1.1) is characterized by mid-statured, cool-season rhizomatous grasses, which commonly comprise 50 percent or more of the total production on the site. Western wheatgrass (*Pascopyrum smithii*) is the predominant species, however thickspike wheatgrass (*Elymus lanceolatus*) may also occur and becomes more common in the northern extent of this site. Needle and thread is the predominant mid-statured bunchgrass on this ecological site and typically comprises approximately 10 percent of the total production. The mat-forming, warm-season perennial grass blue grama is the most common shortgrass in this phase, although prairie Junegrass (*Koeleria macrantha*) and Sandberg bluegrass may also be present. Common forbs are scarlet globemallow (*Sphaeralcea coccinea*), spiny, or Hood's, phlox (*Phlox hoodii*), and upright prairie coneflower (*Ratibida columnifera*). Shrubs and subshrubs such as prairie sagewort (*Artemisia frigida*) and silver sagebrush (*Artemisia cana*) occur at approximately 5 percent cover. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Rhizomatous Wheatgrass 50%
Needle and Thread 10%
Blue Grama 5%
Other Native Grasses 15%
Perennial Forbs 15%
Shrubs/Subshrubs 5%

Estimated Total Annual Production (lbs/ac)*
Low - 800
Representative Value - 1,100
High - 1,400
* Estimated based on current data – subject to revision

Phase 1.2: At-Risk Community Phase
The At-Risk Community Phase (1.2) occurs when site conditions decline due to drought or improper grazing management. Multiple fires in close succession can also transition the site to this phase. It is characterized by nearly equal proportions of rhizomatous wheatgrasses and shortgrasses. Rhizomatous wheatgrasses that are in decline have been substantially reduced in both cover and vigor. Mid-statured bunchgrasses such as needle and thread are rare or absent. Shortgrasses such as blue grama, Sandberg bluegrass, and prairie Junegrass are increasing. Prairie sagewort may also increase in this phase.

Community Phase Pathway 1.1a
Drought, improper grazing management, multiple fires in close succession, or a combination of these factors can shift the Mixedgrass Community Phase (1.1) to the At-Risk Community Phase (1.2). These factors favor an increase in shortgrasses such as blue grama and a decrease in midgrasses (Coupland, 1961; Shay et al., 2001).

Community Phase Pathway 1.2a
Normal or above-normal spring precipitation and proper grazing management transitions the At-Risk Community Phase (1.2) back to the Mixedgrass Community Phase (1.1).

Transition T1A
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). The Reference State (1) transitions to the Shortgrass State (2) when mid-statured grasses become rare and contribute little to production. Shortgrasses such as blue grama, prairie Junegrass, and Sandberg bluegrass dominate the plant community.

Transition T1B
The Reference State (1) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Reference State (1). The most common concerns are introduced bluegrasses, which are widespread invasive species in the northern Great Plains (Toledo et al., 2014). Studies have shown that exclusion of grazing and fire favors invasive bluegrass species (DeKeyser et al., 2013). In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference State (1).

Transition T1C
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Reference State (1) to the Cropland State (4).

State 2: Shortgrass State
The Shortgrass State 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; Derner and Whitman, 2009). Blue grama-dominated communities in particular, 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). Dense clubmoss cover varies from rare to abundant. Its dynamics are not well understood, however, and 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).

Phase 2.1: Shortgrass Community Phase
The Shortgrass Community Phase (2.1), occurs when site conditions decline due to long-term drought or improper grazing. Mid-statured grasses have been largely eliminated and replaced by short-statured species, such as blue grama, prairie Junegrass, and Sandberg bluegrass. Blue grama resists grazing due to its low stature and extensive root system. The subshrub, prairie sagewort is common.

Transition T2A
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). The most common concerns are introduced bluegrasses, which are widespread invasive species in the northern Great Plains (Toledo et al., 2014). Decreased vigor of native species may be one factor that increases susceptibility to invasion. Studies have also shown that exclusion of grazing and fire favors invasive bluegrass species (DeKeyser et al., 2013). In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference State (1).

Transition T2B
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Shortgrass State (2) to the Cropland State (4).

Restoration Pathway R2A
A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of shortgrasses in the Shortgrass State (2) (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 (2) to the Reference State (1) can require considerable energy and cost and may not be feasible within a reasonable amount of time.

State 3: Invaded State
The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Introduced bluegrasses, such as Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*Poa compressa*), are the most widespread concerns. Kentucky bluegrass, in particular, is widespread throughout the Northern Great Plains (Toledo et al., 2014). It is very competitive and displaces native species by forming dense root mats, altering nitrogen cycling, and creating allelopathic effects on germination (DeKeyser et al., 2013). Plant communities

dominated by Kentucky bluegrass have significantly less cover of native grass and forb species (Toledo et al., 2014; Dekeyser et al., 2009). Effects on soil quality are still unknown at this time, but possible concerns are alteration of surface hydrology and modification of soil surface structure (Toledo et al., 2014). Invasive grass species appear to be capable of invading any phase of the Reference State (1), regardless of grazing management practices, and have been found to substantially increase under long-term grazing exclusion (DeKeyser et al., 2009, 2013; Grant et al., 2009). Reduced plant species diversity, simplified structural complexity, and altered biologic processes result in a state that is substantially departed from the Reference State (1).

Noxious weeds such as leafy spurge and Canada thistle are not widespread in MLRA 52, but they do have the potential to invade this site. 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 Reference State (1). However, cessation of control methods will most likely result in recolonization of the site by the noxious species.

Transition T3A
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Invaded State (3) to the Cropland State (4).

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

Transition T4A
The transition from the 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 seedings may be comprised of introduced grasses and legumes, or a mix of native species.

State 5: Post-Cropland State
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 grazing or wildlife use. The Post-Cropland State (5) can transition back to the Cropland State (4) if the site is put back into cultivation.

Phase 5.1: Abandoned Cropland Community Phase
In the absence of active management, the site can re-vegetate naturally and, over time, potentially return to a perennial grassland community with needle and thread 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. Cover and production of cool-season rhizomatous wheatgrasses are low, even after several decades (Dormaar and Smoliak, 1985; Dormaar et al., 1994; Christian and Wilson, 1999). Invasion of the site by exotic species, such as 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 Reference State (1). However, soil quality is consistently lower than conditions prior to cultivation (Dormaar and Smoliak, 1985; Christian and Wilson, 1999) and a shift to the Reference State (1) is unlikely within a reasonable timeframe.

Phase 5.2: Perennial Grass Community Phase
When the site is seeded to perennial forage species, particularly introduced perennial grasses, this community phase can persist for several decades. Some introduced species, such as smooth brome, are very aggressive, frequently form a monoculture, 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 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 (Dormaar et al., 1994).

Transition 5A

The Post-Cropland State (5) transitions back to the Cropland State (4) when the site is converted

State and transition model

Claypan

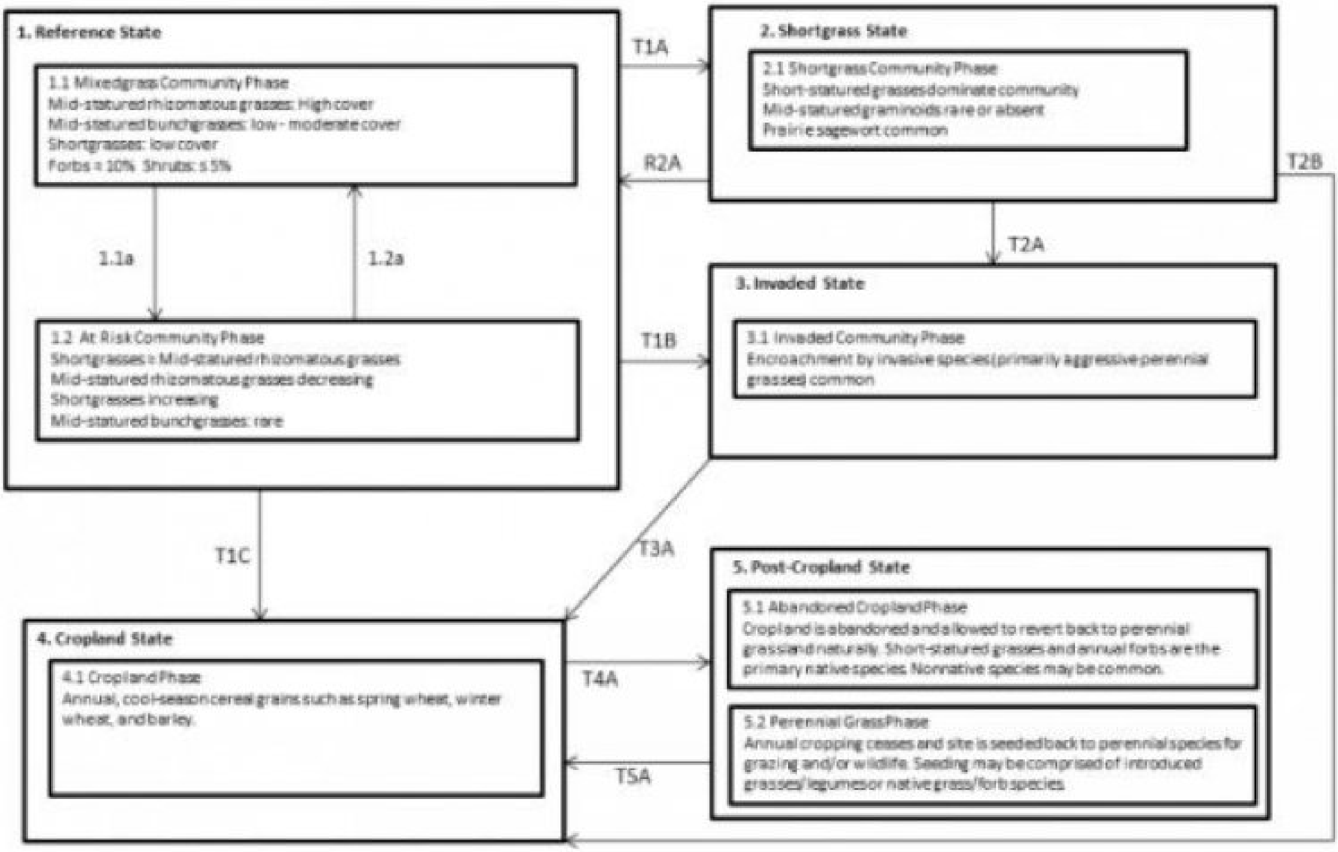

Figure 2. State-and-transition diagram

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Claypan

Legend

- 1.1a drought, improper grazing management, multiple fires in close succession
- 1.2a normal or above-normal spring moisture, proper grazing management
- T1A prolonged drought, improper grazing, or a combination of these factors
- T1B introduction of non-native invasive species (primarily crested wheatgrass)
- T2A introduction of weedy species; combined with drought and/or improper grazing management
- R2A range seeding, grazing land mechanical treatment, normal or above-normal moisture, proper grazing management (management intensive and costly)
- T1C, T2B, T3A, T5A conversion to cropland
- T4A cessation of annual cropping

Animal community

Livestock Grazing Interpretations: Managed livestock grazing is suitable on this site as it has the potential to produce a limited amount of high quality forage. Grazing must be managed carefully on this site to be sure livestock drift onto the better, more productive, and more accessible sites is not excessive. Management objectives should include maintenance or improvement of the native plant community. Livestock accessibility is a significant limitation with this ecological site.

Using shorter grazing periods and providing for adequate re-growth after grazing are recommended for plant maintenance, health, and recovery. Continual non prescribed grazing of this site can be detrimental and will alter the plant composition and production over time. The result will be plant communities that resemble numbers 3 and 4, depending on how long this grazing management is used as well as other circumstances such as weather conditions and fire frequency.

Whenever Plant Community 2 (medium and short grasses) occurs, grazing management strategies that will prevent further degradation need to be implemented. This community is still stable, productive, and healthy provided it receives proper management. It will respond fairly quickly to improved grazing management, including increased growing season rest of key forage plants. Grazing management alone can usually move this back towards the potential / historic climax community.

Plant community 3 is the result of long-term, heavy, continuous grazing and/or annual, early spring seasonal grazing. Repeated heavy early spring grazing, especially during stem elongation (generally mid May through mid June), can also have detrimental affects on the taller, key forage species. Repeated spring grazing depletes stored carbohydrates, resulting in weakening and eventual death of the cool season tall and medium grasses. This plant community can occur throughout the pasture, on spot grazed areas, and around water sources where season-long grazing patterns occur.

It becomes critical at this point to implement a grazing strategy that will restore the stability and health of the site. Additional growing season rest, often combined with facilitating practices (e.g., water developments, fencing), is usually necessary for re-establishment of the desired native species and to restore the stability and health of the site.

Hydrological functions

The runoff potential for this site is very high depending on slope and ground cover/health. Runoff curve numbers generally range from 84 to 93. The soils associated with this ecological site are generally in Hydrologic Soil Group D. The infiltration rates for these soils will normally be very slow.

The hydrologic condition of this site has a significant affect on runoff. The hydrologic condition considers the effects of cover, including litter, and management on infiltration. Good hydrologic condition indicates that the site usually has a lower runoff potential. Plant cover and litter helps retain soil moisture for use by the plants. Maintaining a healthy stand of perennial native vegetation with deep root systems will optimize the amount of precipitation that is received, help maintain or increase infiltration rates and reduce runoff.

For arid and semi-arid rangelands, good hydrologic conditions exist if cover (grass, litter, and brush canopy) is greater than 70%. Fair conditions exist when cover is between 30 and 70%, and poor conditions exist when cover is less than 30%.

Sites in high similarity (Plant Communities 1 & 2) generally have enough plant cover and litter to optimize infiltration, minimize runoff and erosion, and have a good hydrologic condition. Erosion is minor for sites in high similarity. Rills and gullies should not be present. Water flow patterns, if present, will be barely observable. Plant pedestals are essentially non-existent. Plant litter remains in place and is not moved by erosion. Soil surfaces should not be compacted or crusted.

Sites in low similarity (Plant Communities 3 and 4) are generally considered to be in less than good hydrologic condition as the majority of plant cover is from shallow rooted species.

Wood products

n/a

Inventory data references

Information presented was derived from NRCS inventory data, National Resources Inventory (NRI) Data, literature, field observations, and personal contacts with range-trained personnel (i.e., used professional opinion of agency specialists, observations of land managers, and outside scientists).

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Contributors

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Approval

Kirt Walstad, 9/07/2023

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	05/04/2024
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:**

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

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

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

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

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

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

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

---

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

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

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

---

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:**