USDA Natural Resources
Conservation Service

Ecological site R046XN630MT
Dense Clay (DC) RRU 46-N 10-14 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, three 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 to 6500 feet (975 to 1981 m) 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 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 & 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 (429mm) 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 from 70 to 117 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

• Site does not receive additional effective moisture
• Soils are natric or have relic natric horizons
• Columnar structure present with abrupt root or water restrictive clay layer present within
4 inches of soil surface

Associated sites

R046XN628MT	**Claypan (Cp) RRU 46-N 13-19 PZ** Claypan typically has higher landscape position above the Dense Clay site

Similar sites

R046XN628MT	**Claypan (Cp) RRU 46-N 13-19 PZ** Similar plant community and STM however produces nearly 50 percent more production.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata* (2) *Artemisia frigida*
Herbaceous	(1) *Pseudoroegneria spicata* (2) *Hesperostipa comata*

Physiographic features

The Dense Clay ecological site exists on nearly level to gently sloping hills, stream terraces, fan remnants, alluvial fans, fans, and terraces. Slopes average 1 to 8 percent with extremely limited areas of up to 15 percent.

Table 2. Representative physiographic features

Landforms	(1) Foothills > Hill (2) Foothills > Stream terrace (3) Foothills > Fan remnant (4) Foothills > Alluvial fan (5) Foothills > Fan (6) Foothills > Terrace
Elevation	853–1,067 m
Slope	0–8%
Aspect	Aspect is not a significant factor

Climatic features

The climate of the Dense Clay site falls into Climatic Subset A. The central concept of Climatic Subset A is 10 to 14 inches Relative Effective Annual Precipitation (REAP) and 70 to 90 days frost-free.

The soil temperature regime for this Dense Clay ecological site is Frigid and the soil moisture regime is Aridic Ustic

Table 3. Representative climatic features

Frost-free period (characteristic range)	79-90 days
Freeze-free period (characteristic range)	118-126 days
Precipitation total (characteristic range)	305-330 mm
Frost-free period (actual range)	75-92 days
Freeze-free period (actual range)	117-130 days
Precipitation total (actual range)	279-356 mm
Frost-free period (average)	84 days
Freeze-free period (average)	122 days
Precipitation total (average)	305 mm

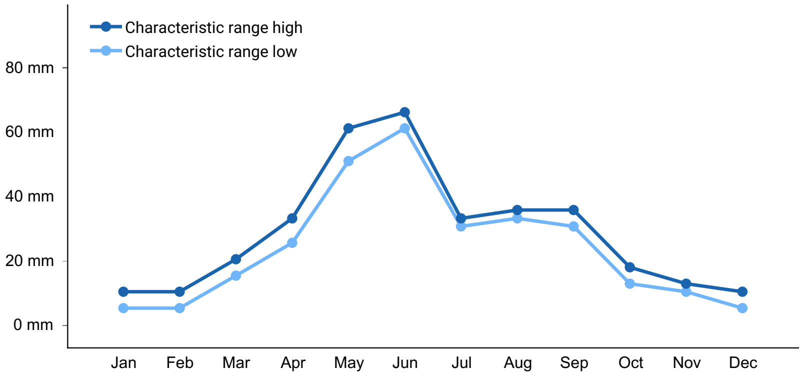

Figure 1. Monthly precipitation range

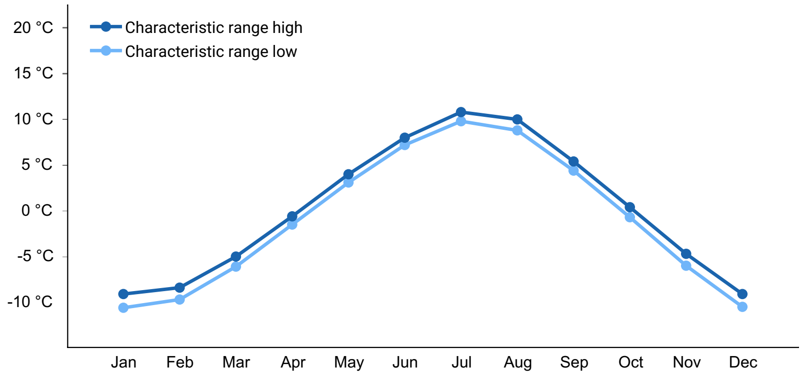

Figure 2. Monthly minimum temperature range

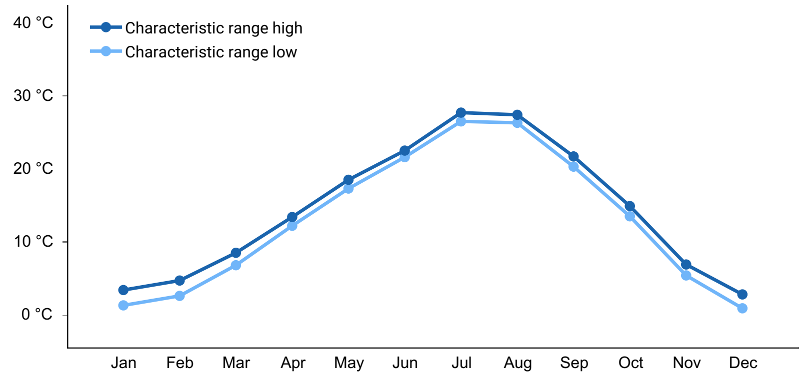

Figure 3. Monthly maximum temperature range

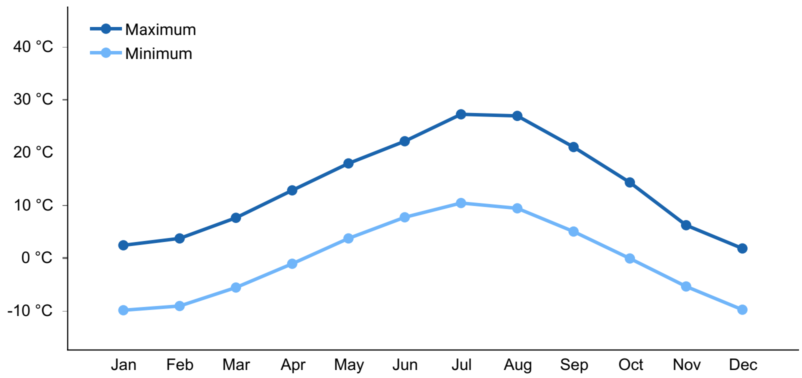

Figure 4. Monthly average minimum and maximum temperature

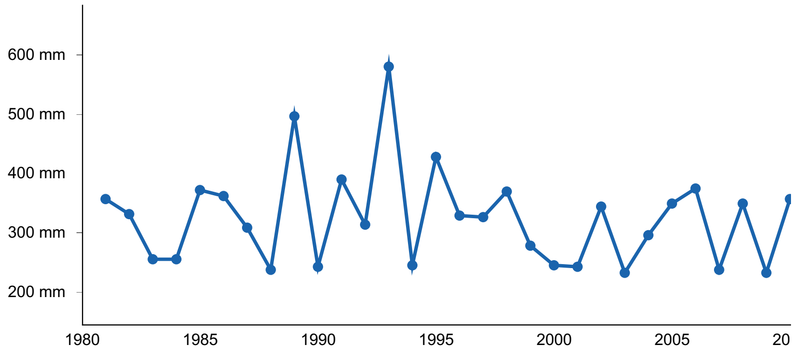

Figure 5. Annual precipitation pattern

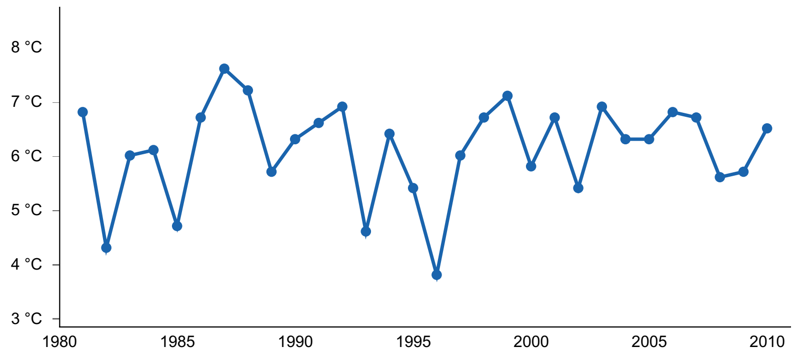

Figure 6. Annual average temperature pattern

Climate stations used

- (1) AUGUSTA [USC00240364], Augusta, MT
- (2) CUT BANK MUNI AP [USW00024137], Cut Bank, MT
- (3) FAIRFIELD [USC00242857], Fairfield, MT

Influencing water features

No influencing water features

Wetland description

Not present

Soil features

These are moderately deep to very deep non-granular clay soils that are strongly to very strongly alkaline near the surface. These soils typically are very hard to extremely hard when dry and very sticky when wet. They typically have a thin vesicular surface crust, which restricts water permeability. The subsoil is either massive, or has a very strong columnar structure. Permeability and root development are severely limited by the surface crust, hard subsoil, and alkalinity.

Surface textures found on this site are most commonly clay, clay loam, silty clay or silty clay loam. The upper four inches of soil contains more than 45 percent clay. The underlying horizons typically contain 40 to 75 percent clay and have clay or silty clay textures. Organic matter in the surface horizon typically ranges from 1 to 3 percent, and moist colors vary from grayish brown (2.5Y 5/2) to dark grayish brown (2.5Y 4/2). Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. Soil pH classes are 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 (greater than 60 inches). Coarse fragments are typically rare or absent in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Alluvium–sedimentary rock
Surface texture	(1) Silty clay loam (2) Clay loam (3) Clay (4) Silty clay
Family particle size	(1) Fine
Drainage class	Moderately well drained to well drained
Permeability class	Moderately slow to slow
Soil depth	51–254 cm
Surface fragment cover <=3"	0–15%
Surface fragment cover >3"	0–5%
Available water capacity (0-101.6cm)	9.14–11.18 cm
Soil reaction (1:1 water) (0-12.7cm)	6.6–9
Subsurface fragment volume <=3" (0-50.8cm)	0–12%
Subsurface fragment volume >3" (0-50.8cm)	0–3%

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 Dense Clay ecological site consists of five states: The Reference State (1.0), the Shortgrass State (2.0), the Invaded State (3.0), the Cropland State (4.0), and the Post-Cropland State (5.0). Plant communities associated with the Dense Clay 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. American bison (Bison bison) were the dominant historic grazer, but pronghorn (Antilocapra americana), elk (Cervus canadensis), and deer (Odocoileus spp.) were also common. Additionally, small mammals such as prairie dogs (Cynomys spp.) and ground squirrels (Urocitellus spp.) also influenced this plant community (Salo et al., 2004). Grasshoppers and periodic outbreaks of Rocky Mountain locusts (Melanoplus spretus; Lockwood, 2004) also played an important role in the ecology of these communities.

The historic ecosystem also experienced relatively frequent 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 historic fire return interval had neutral or slightly positive effects on the plant community (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). Conversely, long-term fire suppression in the 20th century removed periodic fire from the ecosystem altogether. Lack of periodic fires can result in an increase in litter accumulation and, in some cases, provide 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 (Ogle et al., 2003; Harmoney, 2007) and can be present in any state within the scope of this ecological site. They typically do not have a significant ecological impact; however, their presence can reduce the production of cool-season perennial grasses in some cases (Haferkamp et al., 1997). Their abundance varies depending on precipitation and germination conditions.

Improper grazing of this site can result in a reduction in the cover of the mid-statured cool-season grasses and an increase in shortgrasses (Smoliak et al., 1972; Smoliak, 1974). Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year and/or that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and/or inadequate seasonal rotation moves over multiple years. Periods of extended drought (approximately 3 years or more) can reduce mid-statured cool-season grasses, triggering an increase in shortgrasses such as prairie Junegrass (Coupland, 1961; Clarke et al., 1947).

Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as prairie Junegrass and Sandberg bluegrass. Mid-statured rhizomatous grasses and bunchgrasses are severely reduced or absent. Cover of prairie sagewort can also increase.

Much of the Dense Clay ecological site has been converted to annual cropland. Seeding of introduced grasses, particularly crested wheatgrass (*Agropyron cristatum*), was a common practice in 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, 1996). 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*) was introduced in the 1950s to provide forage for livestock (Dormaar et al., 1995). Although less widespread, it is also a common pasture species in MLRA 46. Russian wildrye is typically planted in monocultures, but this species is not considered invasive and is unlikely to spread into undisturbed grasslands (Ogle et al., 2012).

When this site is taken out of production, this ecological site is either allowed to revert back to perennial grassland or is seeded with introduced species. Sites left to undergo natural plant succession after cultivation can, over several decades, support western wheatgrass 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). Even when reseeded to native species, it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar and Willlms, 1990).

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, 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 contains two community phases. 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 phase was resilient to grazing and fire, although these factors could influence species composition in localized areas. Vegetation is characterized by mid-statured cool-season rhizomatous grasses, mid-statured bunchgrasses, and short-statured grasses.

Community Phase 1.1: Rhizomatous Wheatgrass Phase
The Rhizomatous Wheatgrass Phase is typically dominated by western wheatgrass. Thickspike wheatgrass may also be present, becoming abundant in the northern extent of this ecological site. The mid-statured bunchgrass green needlegrass is common. Short-statured grasses such as prairie Junegrass and Sandberg bluegrass (*Poa secunda*) are not abundant in this phase but are generally present at low cover. Forbs typically comprise approximately 10 percent of the total production. Silver sagebrush (*Artemisia cana*) is the predominant sagebrush

species and is present at 5 percent cover or less. The approximate species composition of the reference plant community is as follows:

Percent composition by weight
Rhizomatous Wheatgrass 40%
Green Needlegrass 20%
Prairie Junegrass 10%
Other Native Grasses 15%
Perennial Forbs 10%
Shrubs/Subshrubs 5%

Estimated Total Annual Production (lbs/ac)*
Low - 400
Representative Value - 650
High - 900
* Estimated based on current observation – subject to revision

Community Phase 1.2: At-Risk Community Phase
In the At-Risk Community Phase, rhizomatous wheatgrasses are in decline and are in nearly equal proportion to shortgrasses. Shortgrasses such as prairie Junegrass and Sandberg bluegrass are increasing. Mid-statured bunchgrasses are rare or absent.

Community Phase Pathway 1.1a
Drought, improper grazing management, or a combination of these factors can shift the Rhizomatous Wheatgrass Phase (1.1) to the At Risk Community Phase (1.2). These factors favor a decrease in cool-season midgrasses and an increase in shortgrasses (Coupland, 1961).

Community Phase Pathway 1.2a
The At-Risk Community Phase (1.2) can return to the Rhizomatous Wheatgrass Phase (1.1) with normal or above-normal spring precipitation and proper grazing management.

Transition T1A
Improper grazing practices, prolonged drought (approximately 3 years or more), 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 transitions to the Shortgrass State when mid-statured cool-season grasses become rare and contribute little to production. Shortgrasses, such as 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). These communities are commonly adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. Other rangeland health attributes, such as reproductive capacity of native grasses (Henderson and Naeth, 2005) and soil quality (Smoliak and Dormaar, 1985; Dormaar et al., 1995), have been substantially altered from the Reference State.

Transition T1C
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, or 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. The site is dominated by shortgrasses while mid-statured grasses have been eliminated or nearly so. Reductions in stocking rates can reduce shortgrass cover and increase the cover of rhizomatous wheatgrasses. This recovery may take decades, especially if soil properties are substantially altered (Dormaar and Willms, 1990).

Community Phase 2.1: Shortgrass Community Phase
The Shortgrass Community Phase is dominated by shortgrasses such as prairie Junegrass and Sandberg

bluegrass. Prairie sagewort may also become common in this phase.

Transition T2A
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). Crested wheatgrass, in particular, is a concern when native plant communities are adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. Other rangeland health attributes, such as reproductive capacity of native grasses (Henderson and Naeth, 2005) and soil quality (Smoliak and Dormaar, 1985; Dormaar et al., 1995), have been substantially altered from the Reference State.

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
Reduction in livestock grazing pressure alone may not be sufficient to restore the Shortgrass State (2) to the Reference State (1) (Dormaar and Willms, 1990). Practices such as range seeding may be necessary (Hart et al., 1985), but these are management 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. Crested wheatgrass is a common concern, especially when native plant communities are adjacent to seeded pastures. An estimated 20 million acres of crested wheatgrass have been planted in the western U.S. (Holechek, 1981). Crested wheatgrass produces abundant seeds that can dominate the seedbank of invaded grasslands (Henderson and Naeth, 2005), although crested wheatgrass cover decreases with increasing distance from seeded areas (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 green needlegrass and prairie Junegrass (Christian and Wilson, 1999; Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Reduced soil quality (Dormaar et al., 1995), reduced plant species diversity, and simplified structural complexity (Henderson and Naeth, 2005) result in a state that is substantially departed from the Reference State (1).

Noxious weeds such as leafy spurge are uncommon on this site but are capable of invading if a seed source is present. These species are very aggressive and 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 46 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. This state can transition back to the

Cropland State (4) if the site is put back into cultivation.

Phase 5.1: Abandoned Cropland Phase
In the absence of active management, the site can re-vegetate naturally and, over time, potentially return to a perennial grassland community with rhizomatous wheatgrasses and shortgrasses. Shortly after cropland is abandoned, annual forbs and grasses invade the site (Samuel and Hart, 1994). The site is highly susceptible to erosion due to the absence of perennial species. Eventually, these pioneering annual species are replaced by perennial species such as western wheatgrass. Depending on the historical management of the site, perennial bunchgrasses may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species, such as crested wheatgrass 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 (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 Phase
When the site is seeded to perennial forage species, particularly introduced perennial grasses, this community phase can persist for several decades. Crested wheatgrass, in particular, is very aggressive and may form monocultures persisting for at least 60 years (Krzic et al., 2000; Henderson and Naeth, 2005). 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 are unlikely return to pre-cultivation conditions within a reasonable timeframe (Dormaar and Willms, 1990).

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

State and transition model

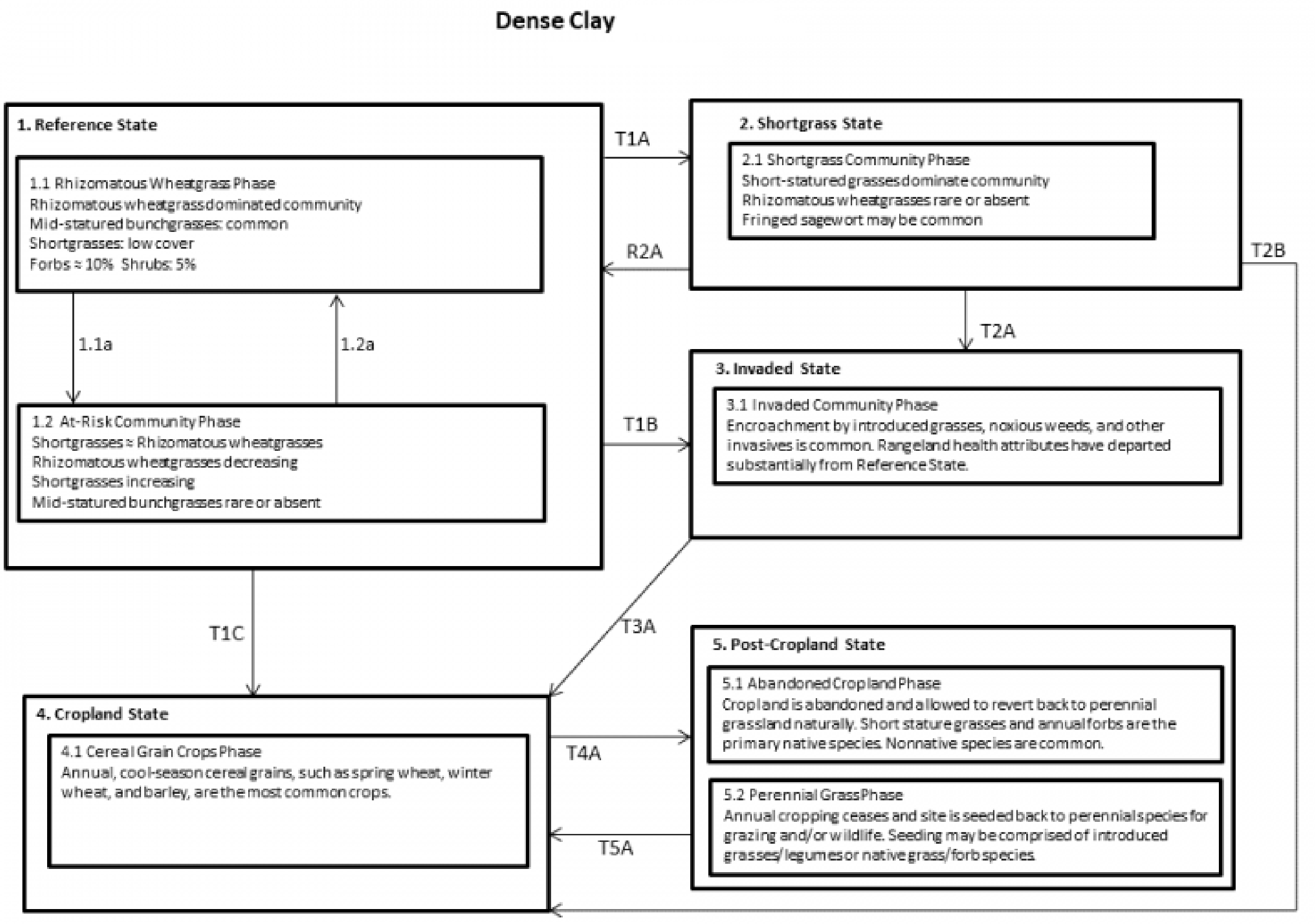

Figure 2. State-and-transition diagram

Dense Clay

Legend

- 1.1a drought, improper grazing management
- 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
- 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

Figure 3. State-and-transition legend

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.

Plant Community 4 has a high percentage of aggressive, less-desirable species. It has lost most of the attributes of a healthy rangeland. Grazing management alone is seldom able to restore the site to one that resembles the Reference State once this plant community has become established. Seeding and/or mechanical treatment on this site is not feasible.

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 percent. Fair conditions exist when cover is between 30 and 70 percent, and poor conditions exist when cover is less than 30 percent.

Sites in high similarity to Reference (Plant Community 1) 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.

Recreational uses

This site provides some recreational opportunities for hiking, horseback riding, big game and upland bird hunting. The forbs have flowers that appeal to photographers. This site provides valuable open space and visual aesthetics. Caution should be used during wet weather periods.

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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Approval

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	Grant Petersen
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Date	08/06/2020
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are expected after rainfall events and rapid snowmelt due to high bare ground percentage.

2. **Presence of water flow patterns:** Water flow patterns are common on this site due to high bare ground and very slow infiltration rate.

3. **Number and height of erosional pedestals or terracettes:** Pedestals and terracettes will exist on steeper slopes (greater than 5 percent). Height is less than 1 inch.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is 45-50%. It consists of randomly scattered patches.

5. **Number of gullies and erosion associated with gullies:** Healed gullies may exist as a result of catastrophic rainfall events however current, active gully erosion will not be present.

6. **Extent of wind scoured, blowouts and/or depositional areas:** Wind scoured, or depositional areas are not evident in the reference condition.

7. **Amount of litter movement (describe size and distance expected to travel):** Due to the high amount of bare ground and potential connectivity between these bare patches, litter movement is expected to be high. Litter is primarily small

leaves and stems travelling up to 10 feet.

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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):** The average soil stability rating is 3-4 under plant canopies and 1-3 in plant interspaces. Surface crusting may exist as a result of the high sodium content. The A horizon is less than 1 inch thick.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil Structure at the surface is platy to weak, fine subangular blocky. A Horizon will be less than 1 inch thick with color, when wet, typically ranging in Value of 6 or less and Chroma of 3 or less.
   Local geology may affect color, it is important to reference the Official Series Description (OSD) for characteristic range.
   https://soilseries.sc.egov.usda.gov/osdname.aspx

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Infiltration of the Dense Clay ecological site is very slow but is well drained. Infiltration is restricted due to high clay and sodium content of the soil. An even distribution of rhizomatous grasses (40%), mid stature bunchgrasses (20%), cool season shortgrasses (22%) along with forbs (10%), shrubs (5%) and warm season shortgrasses (3%)

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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):** A compaction layer is not present in the reference condition. Soil profile may contain an abrupt transition to an Argillic horizon which can be misinterpreted as compaction, however, the soil structure will be fine to medium subangular blocky, where a compaction layer will be platy or structureless (massive).

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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: rhizomatous grasses (western wheatgrass) ≥ mid-statured, cool season, perennial bunchgrasses (green needlegrass)

    Sub-dominant: cool season shortgrasses/grasslikes (Sandberg bluegrass, prairie Junegrass) ≥ shrubs > forbs > warm season shortgrasses

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Mortality in herbaceous species is not evident. Species with bunch growth forms may have some natural mortality in centers is 3% or less.

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14. **Average percent litter cover (%) and depth (in):** Total litter cover ranges from 25-35%. Most litter is irregularly distributed on the soil surface and is not at a measurable depth.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** Low - 400
Representative Value - 650
High - 900

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

    Native species such as broom snakeweed, Sandberg's bluegrass, blue grama, pricklypear cactus, greasewood, etc. when their populations are significant enough to affect ecological function, indicate site condition departure.

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17. **Perennial plant reproductive capability:** In the reference condition, all plants are vigorous enough for reproduction either by seed or rhizomes in order to balance natural mortality with species recruitment.
