Ecological site FX052X02X005
Clayey-Steep (Cystp) Moist Grassland

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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): 052X–Brown Glaciated Plains

The Brown Glaciated Plains, MLRA 52, is an expansive, agriculturally and ecologically significant area. It consists of approximately 14.5 million acres and 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. 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 common. Till deposits are typically less than 50 feet thick, and in some areas glacially deformed bedrock occurs at or near the soil surface (Soller, 2001). Underlying the till is sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007). The bedrock is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur along glacial outwash channels and major drainages, including 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, and the maximum glacial extent occurred 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. Crop-fallow dryland wheat farming is the predominant land use. Areas of rangeland typically are on steep hillslopes along drainages.

The rangeland, much of which is native mixedgrass 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 occurring on the type of level 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. Due to erosion and dissection of the landscape, many of these areas have steeper slopes and more exposed bedrock than areas glaciated during the Wisconsin age (Fullerton and Colton, 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 climatic zone represents the northernmost extent of the big sagebrush (Artemisia tridentata) steppe on the Great Plains. Because 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. However, the precise factors are not fully understood at this time.

Sizeable 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 because many individuals overwinter in the big sagebrush steppe (dry shrubland) in the southern portion of the MLRA and then migrate to the northern portion of the MLRA, which lacks big sagebrush (dry grassland), to live the 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, 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 rather than just bi-annually, as 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 (MLRA): 052 Brown Glaciated Plains
• Climate Zone: Moist 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 - Nassella viridula* 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)
Glaciated Northern Grasslands (42j)
Cherry Patch Moraines (42m)
Milk River Pothole Upland (42n)

Ecological site concept

This provisional ecological site occurs in the Moist Grassland climatic zone of MLRA 52. Figure 1 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. Onsite evaluations are necessary, particularly in boundary or intergrade areas where ecological sites from multiple climate zones may overlap. Clayey Steep Moist Grassland is an ecological site of limited extent occurring on areas of the till plain near the various mountain ranges as well as the Sweetgrass Hills in MLRA 52. This ecological site occurs on till plains, lake plains, outwash fans, and alluvial fans where slopes are less than 15 percent.

The distinguishing characteristic of this site is that it contains greater than 35 percent, but not more than 45 percent, clay in the upper 4 inches of soil and it occurs on moderately steep to very steep slopes. Soils for this ecological site are typically moderately deep to very deep (more than 20 inches to bedrock) and derived from clayey till, or clayey residuum deposits. Soil surface textures (0 to 4 inches) are typically clay, clay loam, or silty clay loam, and the soils typically have an ochric epipedon. Characteristic vegetation is western wheatgrass (*Pascopyrum smithii*) and green needlegrass (*Nassella viridula*). Thickspike wheatgrass (*Elymus lanceolatus*) becomes more common in the northern extent of MLRA 52. Shrubs and subshrubs typically comprise 5 percent of the cover or less.

Associated sites

FX052X02X001	**Clayey (Cy) Moist Grassland** This site occurs adjacent to the Clayey Steep Moist Grassland ecological site where slopes are less than 15 percent. It typically occupies a summit position upslope from the Clayey Steep Moist Grassland ecological site.
FX052X02X131	**Shallow Clay (Swc) Moist Grassland** This site occurs on moderate to steeply sloping hillslopes adjacent to the Clayey Steep Moist Grassland ecological site. It occurs in backslope positions where bedrock occurs near the soil surface.

Similar sites

FX052X02X001	**Clayey (Cy) Moist Grassland** This site differs from Clayey Steep Moist Grassland ecological site in that slopes are less than 15 percent.
FX052X02X131	**Shallow Clay (Swc) Moist Grassland** This site differs from Clayey Steep Moist Grassland ecological site in that depth to bedrock or paralithic bedrock is less than 20 inches.
FX052X02X040	**Loamy-Steep (Lostp) Moist Grassland** This site differs from Clayey Steep Moist Grassland ecological site in that soils contain 35 percent or less clay in the upper 4 inches whereas the Clayey Steep Moist Grassland ecological site contains more than 35 percent clay in the upper 4 inches.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY734MT

Physiographic features

Clayey Steep Moist Grassland is an ecological site of limited extent occurring in the moist areas of MLRA 52. The majority of MLRA 52 is covered by a broad till plain, and this ecological site largely occurs at higher elevations near the various mountain ranges and the Sweetgrass Hills. It mostly occurs in backslope positions on hillslopes and bluffs. Slopes vary from 15 to 60 percent.

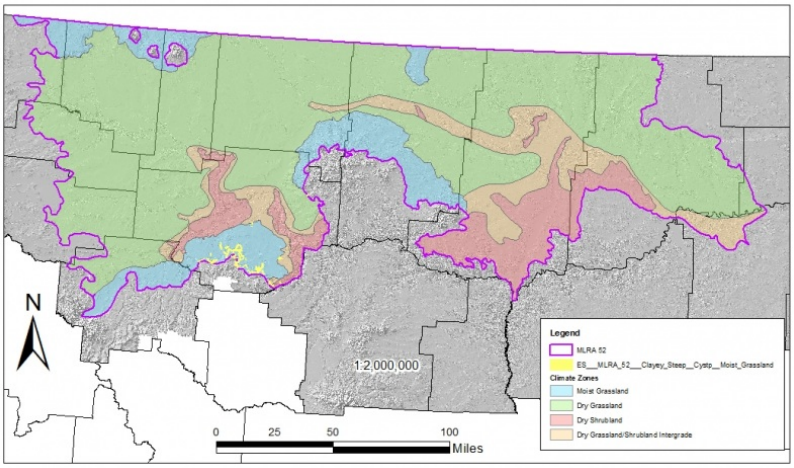


Figure 1. Figure 1. General distribution of the Clayey Steep Moist Grassland ecological site by map unit extent.

Table 2. Representative physiographic features

Hillslope profile	(1) Backslope
Landforms	(1) Till plain > Hillslope (2) Till plain > Bluff
Elevation	3,600–4,590 ft
Slope	15–60%
Aspect	Aspect is not a significant factor

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 110 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 10 years. Annual precipitation ranges from 13 to 17 inches, 70 to 80 percent of which 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 a reaction of plants to a “false spring” (Oard, 1993).

Table 3. Representative climatic features

Frost-free period (average)	110 days
Freeze-free period (average)	135 days
Precipitation total (average)	15 in

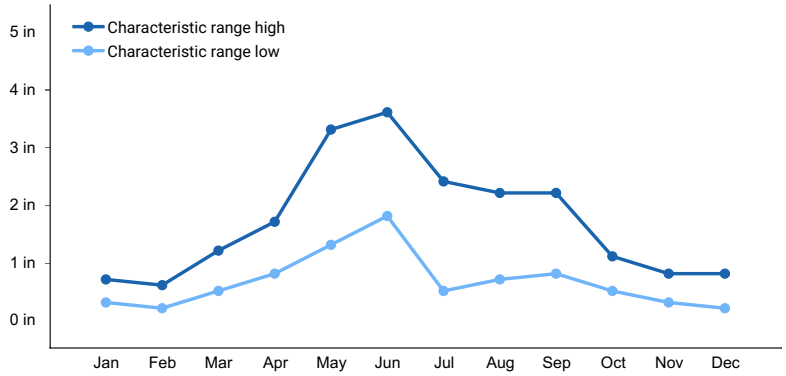


Figure 2. Monthly precipitation range

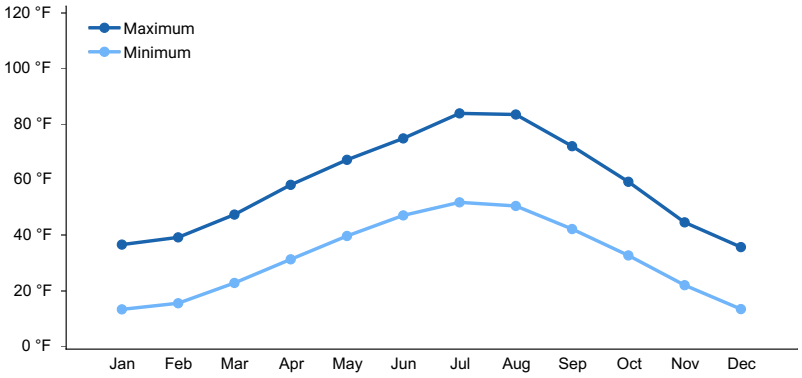


Figure 3. Monthly average minimum and maximum temperature

Climate stations used

- (1) GERALDINE [USC00243445], Geraldine, MT
- (2) GOLDBUTTE 7 N [USC00243617], Sunburst, MT

Influencing water features

This is a semi-arid, upland ecological site and the water budget is normally contained within the soil pedon. During intense precipitation events, precipitation rates frequently exceed infiltration rates and this site delivers moisture to downslope sites via surface runoff. Moisture loss through evapotranspiration exceeds precipitation for the majority of the growing season. Soil moisture levels are greatest in May and June but rarely reach field capacity in the upper 40 inches. Soil moisture is the primary limiting factor for plant production on this ecological site.

Soil features

The soil series that best represents the central concept of this ecological site is Sagedale, but only when it occurs on slopes 15 percent or greater. The Sagedale soil is in the Haplustepts great group. It is characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon and by weakly developed underlying horizons. This soil has smectitic minerology and is in the fine family, meaning it contains between 35 and 60 percent clay in the particle-size control section. The soil moisture regime for this 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 textures found in this site are most commonly clay, silty clay, clay loam, or silty clay loam. The upper 4 inches of soil contains greater than 35 percent, but not more than 45 percent, clay. The underlying horizons typically contain 35 to 60 percent clay and have clay, clay loam, or silty clay loam textures. Organic matter content in the surface horizon typically ranges from 1 to 2 percent, and moist colors vary from dark yellowish brown (10YR 4/4) to dark brown (10YR 3/3). Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH class 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 (more than 20 inches to bedrock) in places where bedrock is present but is typically very deep. Content of coarse fragments is less than 35 percent in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Till (2) Alluvium
Surface texture	(1) Clay (2) Silty clay (3) Clay loam (4) Silty clay loam
Drainage class	Well drained
Soil depth	20–72 in
Available water capacity (0-40in)	6.2–6.5 in
Calcium carbonate equivalent (0-5in)	0–14%
Electrical conductivity (0-20in)	0–3 mmhos/cm
Sodium adsorption ratio (0-20in)	0–12
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) (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 Clayey Steep Moist Grassland provisional ecological site in MLRA 52 Dry Grassland consists of three states: The Reference State (1), the Shortgrass State (2), and the Invaded State (3). 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). It is not known how significant fire was on the Clayey Steep Moist Grassland ecological site. It is believed that the frequency of fire would be less than that of adjacent sites due to the broken topography but further investigation of fire dynamics is needed to better assess this.

Improper grazing of this site can result in a reduction in the cover of the mid-statured bunchgrasses, an eventual decrease in cool-season rhizomatous wheatgrasses, 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 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 inadequate seasonal rotation moves over multiple years. Periods of extended drought (approximately 3 years or more) can reduce mid-statured bunchgrasses and cool-season rhizomatous wheatgrasses, triggering an increase in shortgrasses such as prairie Junegrass (*Koeleria macrantha*) (Coupland, 1958, 1961). Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as prairie Junegrass and blue grama (*Bouteloua gracilis*). The cover of mid-statured rhizomatous grasses and bunchgrasses is severely reduced or absent. The cover of prairie sagewort can also increase.

Due to the steep slopes, this ecological site is generally not suitable for cropland. In general, this site has remained intact, although many acres have been invaded by aggressive, perennial introduced grasses. 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.

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 (Figure 2). 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. 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.

Phase 1.1: Mixedgrass Community Phase
The Mixedgrass Community Phase (1.1) is characterized by mid-statured rhizomatous wheatgrasses and mid-statured bunchgrasses. Rhizomatous wheatgrasses include both western wheatgrass (*Pascopyrum smithii*) and thickspike wheatgrass (*Elymus lanceolatus*). The predominant mid-statured bunchgrass on this ecological site is green needlegrass (*Nassella viridula*). Plains muhly (*Muhlenbergia cuspidata*) may also be present on this site, particularly on south-facing slopes. Bluebunch wheatgrass (*Pseudoroegneria spicata*) may occur on this site, but is typically limited to the southwest portions near the Highwood Mountains. Short-statured grasses such as prairie Junegrass and blue grama are not abundant in this phase but are generally present at low cover. Common forbs are Indian breadroot (Pediomelum spp.), 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 35%
Green Needlegrass 20%
Plains Muhly 5-15%
Prairie Junegrass 5%

Other Native Grasses 5-15%
Perennial Forbs 15%
Shrubs/Subshrubs 5%

Estimated Total Annual Production (lbs/ac)*
Low - Insufficient data
Representative Value - 1,100
High - Insufficient data
* 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. It is characterized by nearly equal proportions of rhizomatous wheatgrasses and shortgrasses. Rhizomatous wheatgrasses are in decline and have been substantially reduced in both cover and vigor. Mid-statured bunchgrasses such as green needlegrass are rare or absent. Shortgrasses such as blue grama and prairie Junegrass are increasing. Prairie sagewort may also increase in this phase.

Community Phase Pathway 1.1a
Drought, improper grazing management, 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 and a decrease in cool-season midgrasses (Coupland, 1961).

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 concern is 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).

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). When abundant, blue grama can alter soil properties, creating conditions that resist establishment of other grass species (Dormaar and Willms, 1990; Dormaar et al., 1994). Reductions in stocking rates can reduce shortgrass cover and increase the cover of cool-season midgrasses, although this recovery may take decades (Dormaar and Willms, 1990, Dormaar et al., 1994).

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 such as green needlegrass and rhizomatous wheatgrasses have been eliminated or nearly so. Short-statured species dominate the plant community. Prairie Junegrass appears to be the predominant species in this phase (Clarke et al., 1947). Blue grama is common but does not appear to be as prevalent on clayey ecological sites as it is on loamy ecological sites. The subshrub, prairie sagewort is also common.

Transition T2A

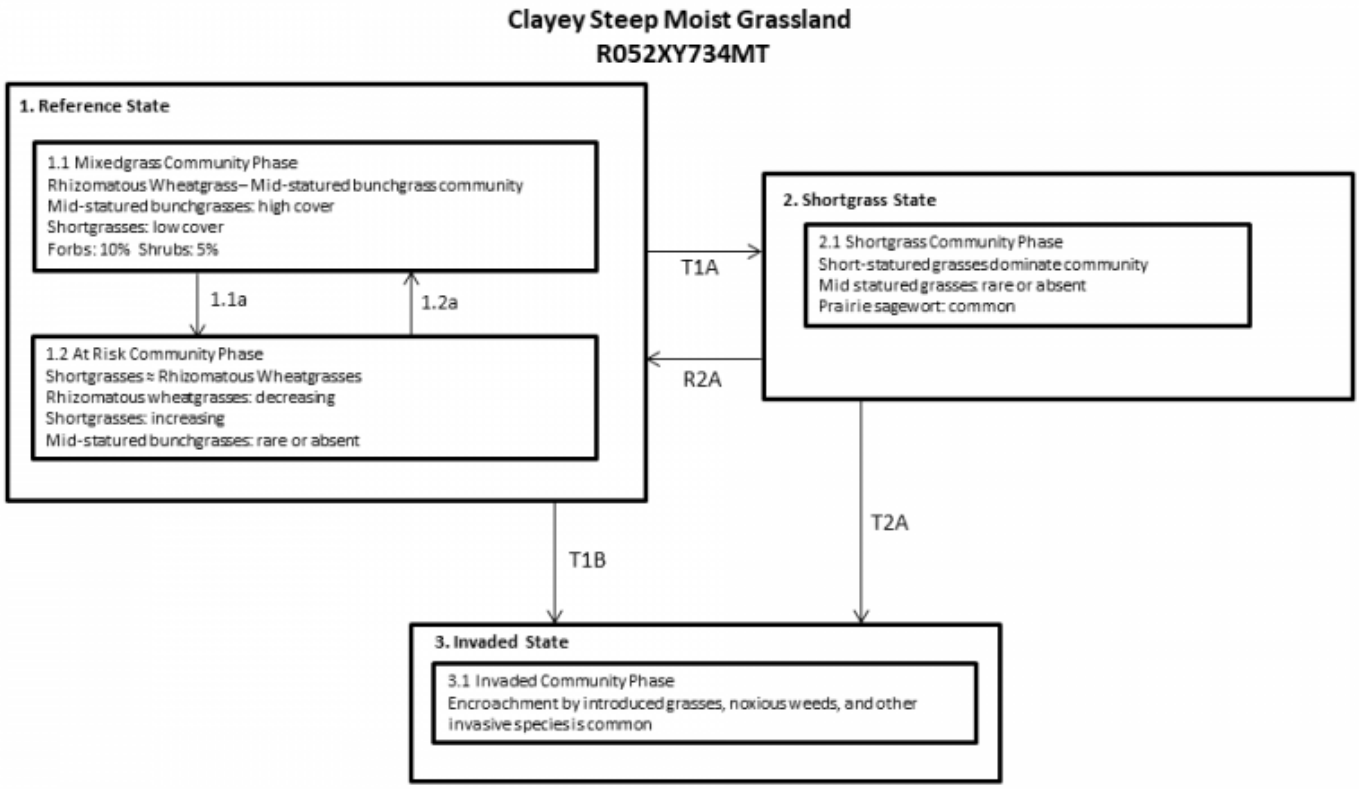
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). The most common concern is introduced bluegrasses, which are widespread invasive species in the northern Great Plains (Toledo et al., 2014). Decreased vigor 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).

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 practices such as grazing land, mechanical treatment, and range seeding may not be possible on this site due to topography. 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). 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). Plant communities dominated by Kentucky bluegrass have significantly less cover of native grass and forb species (Toledo et al., 2014; DeKeyser 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 are not widespread in MLRA 52, but they do have the potential to invade this site. These species are very aggressive perennials that 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.

State and transition model



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 (primarily crested wheatgrass)
T2A - introduction of weedy species; combined with drought and improper grazing management
R2A - range seeding, normal or above-normal moisture, intensive grazing management (management intensive and costly)

Figure 2. State and Transition Model Diagram.

Inventory data references

One low-intensity plot was available for this provisional ecological site. This plot was used in conjunction with a review of the scientific literature and professional experience to approximate the reference plant community. Information for remaining states was obtained from professional experience and a review of the scientific literature. All community phases are considered provisional based on these plots and the sources identified in this ecological site description.

Other references

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Contributors

Scott Brady
Stuart Veith

Approval

Scott Brady, 8/16/2019

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Bill Drummond, USDA-NRCS
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Peer Review and Beta Testing
Kirt Walstad, USDA-NRCS
Kyle Steele, formerly USDA-NRCS
Kelsey Molloy, USDA-NRCS
Rick Caquelin, USDA-NRCS
Josh Sorlie, USDI-BLM
BJ Rhodes, USDI-BLM

Editing
Ann Kinney, USDA-NRCS
Jenny Sutherland, USDA-NRCS

Quality Control
Kirt Walstad, USDA-NRCS

Quality Assurance
Stacey Clark, USDA-NRCS

Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
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:

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17. **Perennial plant reproductive capability:**
