USDA Natural Resources Conservation Service

Ecological site FX052X02X110
Sandy (Sy) Moist Grassland

Last updated: 8/27/2019
Accessed: 04/20/2024

General information

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

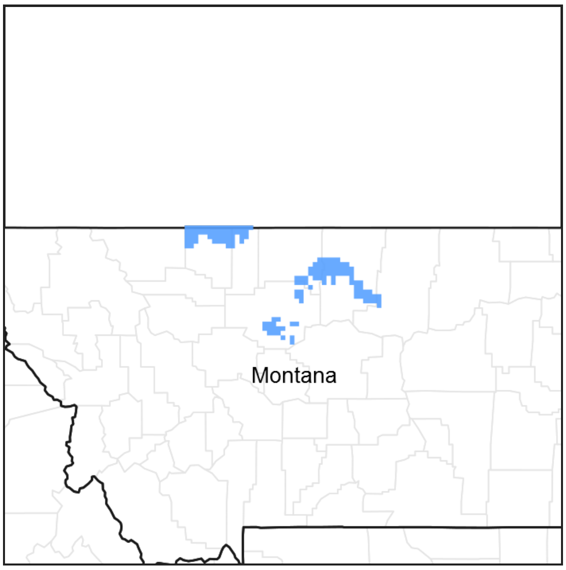

Figure 1. Mapped extent

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

MLRA notes

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

The Brown Glaciated Plains, MLRA 52, is an expansive, 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: Andropogon hallii - Calamovilfa longifolia - Artemisia filifolia Great Plains Sand Grassland and Shrubland Macrogroup (2.B.2.Nb.4)
• Group: Andropogon hallii - Calamovilfa longifolia - Hesperostipa comata Sand Grassland Group (2.B.2.Nb.4.b)
• Alliance: Calamovilfa longifolia Sand Prairie Alliance

• Association: Calamovilfa longifolia - Hesperostipa comata Grassland

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. Sandy 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 alluvial fans, outwash fans and terraces. This site can be found on any slope or slope shape.

The distinguishing characteristics of this site are coarse-loamy textures in the upper 4 inches of soil and a relatively undeveloped soil profile (Soil Survey Staff, 2014). Typically, soil surface textures contain less than 18 percent clay and less than 70 percent sand, but sand content may be higher in some instances. Soils for this ecological site are typically deep to very deep (more than 40 inches) and derived primarily from alluvium or glacial outwash. Species composition is dominated by drought-tolerant plants with deep, extensive root systems. Characteristic vegetation is needle and thread (Hesperostipa comata), rhizomatous wheatgrasses, and prairie sandreed (Calamovilfa longifolia).

Associated sites

FX052X02X032	**Loamy (Lo) Moist Grassland** This site occurs adjacent to the Sandy Moist Grassland ecological site on similar landforms. It generally occurs on similar landscape positions, but occupies areas with fine-loamy textured soils such as ground moraines rather than outwash fans or alluvial fans.
FX052X02X030	**Limy (Ly) Moist Grassland** This site occurs adjacent to Sandy Moist Grassland ecological site on similar landforms. It is generally in positions with a convex slope shape and occupies areas with fine-loamy textured soils such as ground moraines rather than outwash fans or alluvial fans.
FX052X02X040	**Loamy-Steep (Lostp) Moist Grassland** This site occurs on moderate to steeply sloping hillslopes adjacent to or downslope from the Sandy Moist Grassland ecological site. It is generally in backslope positions with a linear or concave slope shape and in areas of fine-loamy textured soils.

Similar sites

FX052X02X032	**Loamy (Lo) Moist Grassland** This site differs from the Sandy Moist Grassland ecological site in that soils contain more than 18 percent clay in the upper 4 inches. Prairie sandreed does not occur on this site.
FX052X02X030	**Limy (Ly) Moist Grassland** This site differs from the Sandy Moist Grassland ecological site in that soils contain more than 18 percent clay in the upper 4 inches and have greater than 5 percent calcium carbonate in the upper 5 inches (evidenced by strong or violet effervescence). Prairie sandreed does not occur on this site.

Table 1. Dominant plant species

Tree	Not specified

Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY747MT

Physiographic features

Sandy 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 occurs on alluvial fans, outwash fans, and terraces. This site can be found on any slope or slope position. Slopes are typically less than 25 percent but may be as steep as 45 percent in some areas.

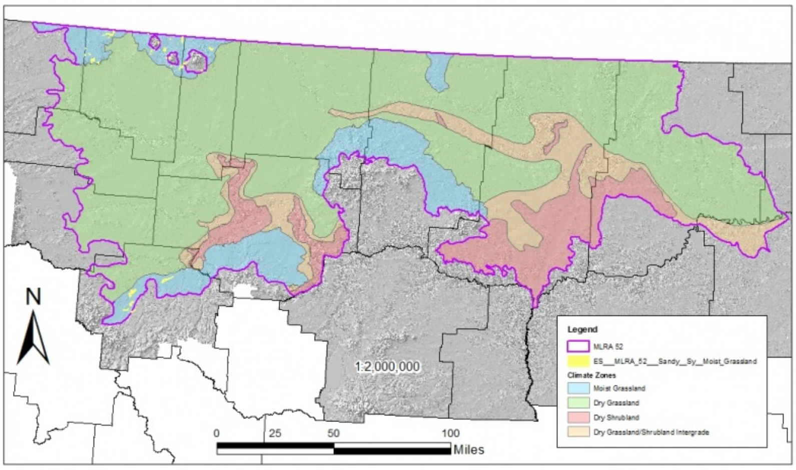

Figure 2. Figure 1. General distribution of the Sandy Moist Grassland ecological site by map unit extent.

Table 2. Representative physiographic features

Landforms	(1) Alluvial fan (2) Outwash fan (3) Terrace
Elevation	3,600–4,590 ft
Slope	0–45%
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

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 contained within the soil profile for the majority of the year. However, the site does function as a recharge site during the spring when rainfall is greatest, especially in wet years. Recharge is typically limited to a localized area and moisture is delivered to adjacent sites via deep percolation or 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 the soil dries out quickly due to the low available water capacity (AWC). When placed into cultivated crops, this site can contribute recharge to saline seeps, which may be a significant concern on adjacent sites.

Soil features

The soil that is most representative of the central concept this ecological site is the Tally series. This soil is in the Haplustolls great group and is characterized by a relatively dark mollic epipedon and an underlying cambic horizon where pedogenic development is present but minimal. The minerology is mixed and particle-size family is coarse loamy, meaning it contains 15 percent or more fine sand and less than 18 percent clay. Soils are primarily derived from glaciofluvial material or alluvium, but this site can be formed in soft sandstone in dissected areas where bedrock is exposed. 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 typically sandy loam or fine sandy loam and contain less than 18 percent clay and less than 70 percent sand. Some sites may have a higher sand content and have textures of loamy sand or loamy fine sand. Underlying horizons typically have weakly developed physical and chemical properties, typically have textures of sandy loam, fine sandy loam, loamy sand or sand, and contain less than 18 percent clay and less than 95 percent sand. Organic matter content in the surface horizon typically ranges from 2 to 5 percent, and moist colors vary from dark brown (10YR 3/3) to very dark brown (10YR 2/2). The upper 5 inches of these soils sometimes reacts strongly or violently with hydrochloric acid. The calcium carbonate equivalent in the upper 5 inches is typically 5 percent or less but may be as high as 10 percent in some cases. The soil depth class for this site can be moderately deep (between 20 to 40 inches to bedrock) where bedrock is present but is typically very deep. Coarse fragments in the upper 20 inches of soil are generally absent.

Table 4. Representative soil features

Parent material	(1) Glaciofluvial deposits (2) Alluvium (3) Residuum
Surface texture	(1) Sandy loam (2) Fine sandy loam
Drainage class	Well drained

Soil depth	20–72 in
Available water capacity (0-40in)	4.8–5.1 in
Calcium carbonate equivalent (0-5in)	0–10%
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 Sandy Moist Grassland provisional ecological site in MLRA 52 Dry Grassland 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 specie 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 Sandy Moist Grassland ecological site. Further investigation of fire dynamics is needed to better assess this concept.

Improper grazing of this site can result in a reduction in the cover of the mid-statured bunchgrasses, a decrease in cool-season wheatgrasses, and an increase in shortgrasses (Smoliak et al., 1972; Smoliak, 1974). Warm-season rhizomatous grasses such as prairie sandreed may also increase (Adams et al., 2013). Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year and/or that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and/or inadequate seasonal rotation moves over multiple years. Periods of extended drought (approximately 3 years or more) can reduce mid-statured, cool-season grasses and shift the species composition of this community to one dominated by shortgrasses (Coupland, 1958, 1961). Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as prairie Junegrass (*Koeleria macrantha*) and blue grama (*Bouteloua gracilis*). This site is also susceptible to invasion by non-native species. Non-native perennial grasses such as bluegrass (Poa spp.) and crested wheatgrass (*Agropyron cristatum*), are the most common invasive species. Bluegrass 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 coarse soil textures and the reduced water-holding capacity, this ecological site is not generally regarded as productive cropland. Regardless, many acres have been cultivated and planted to crops. The most common crops are cereal grain crops, such as winter wheat, spring wheat, and barley. When taken out of production, this site is either allowed to revert back to perennial grassland or is seeded back to perennial grass. Such seedings may be comprised of introduced grasses and legumes or a mix of native species. Sites left to undergo natural plant succession after cultivation can, over several decades, support native vegetation similar to the Reference State (1) (Christian and Wilson, 1999) although it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar 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 bunchgrasses, mid-statured rhizomatous wheatgrasses, and warm-season rhizomatous grasses. This state evolved under the combined influences of climate, grazing, and fire with climatic variation having the greatest influence on cover and production. Available data suggests that this ecological site is particularly sensitive to climatic variability with fluctuations in total annual production well over 1,000 pounds per acre. It is believed that the coarse texture of the soil contributes to this extreme variability, but further study is needed to assess this concept. In general, this state was resilient to grazing, although heavy grazing could influence species composition in localized areas. Fire dynamics are not well understood on this site.

Phase 1.1: Mixedgrass Community Phase
The Mixedgrass Community Phase (1.1) is characterized by mid-statured bunchgrasses, mid-statured rhizomatous wheatgrasses, and prairie sandreed. The predominant bunchgrass species is needle and thread but western porcupinegrass (*Hesperostipa curtiseta*) increases in abundance as mean annual precipitation increases. Rhizomatous wheatgrasses include both western wheatgrass (*Pascopyrum smithii*) and thickspike wheatgrass (*Elymus lanceolatus*). Prairie sandreed is common and becomes more abundant as soil textures become coarser. Prairie Junegrass (*Koeleria macrantha*) is the most common shortgrass in this phase, but blue grama and Sandberg bluegrass (*Poa secunda*) may also occur. Sedges such as threadleaf sedge (*Carex filifolia*) are also common at low cover. Common forbs include dotted blazing star (*Liatris punctata*) and hairy false goldenaster (*Heterotheca villosa*). Shrubs and subshrubs are rare on this site, but prairie sagewort (*Artemisia frigida*) and silver sagebrush (*Artemisia cana*) can occur, particularly on finer textured soils. Coarser textured soils may also support trace amounts of prairie rose (*Rosa arkansana*). The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Mid-Statured Bunchgrasses 30-40%
Needle and Thread (5-40%)
Western Porcupinegrass (0-25%)

Rhizomatous Wheatgrass 15-25%

Prairie Sandreed 5-25%
Prairie Junegrass 10%
Other Native Grasses 15%
Perennial Forbs 5%
Shrubs/Subshrubs 1-5%

Estimated Total Annual Production (lbs/ac)*
Low - 650
Representative Value - 900
High - 1,150
* 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 a prairie sandreed-shortgrass plant community. Rhizomatous wheatgrasses have been substantially reduced in both cover and vigor and have become rare. Mid-statured bunchgrasses such as needle and thread are also decreasing. Prairie sandreed may increase along with other grazing resistant species such as prairie Junegrass, sedge, and prairie sagewort (Adams et al., 2013).

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 grazing resistant species such as prairie sandreed and prairie Junegrass, and a decrease in midgrasses (Coupland, 1961, Adams et al., 2013).

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 prairie Junegrass, blue grama, 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 and crested wheatgrass. Bluegrasses in particular, 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 (Dekayser 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 (2) 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).

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 rhizomatous wheatgrasses, needle and thread, and western porcupinegrass have been largely eliminated. Short-statured species such as prairie Junegrass, blue grama, and Sandberg bluegrass dominate the plant community. Threadleaf sedge may also present and the subshrub, prairie sagewort is common. Bare ground is high and erosional patterns and plant pedestaling are evident.

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 and crested wheatgrass. Bluegrasses in particular, 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 (Dekayser 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 treatments may be necessary (Hart et al., 1985), but practices such as mechanical treatment of grazing land and range seeding should be used with caution on this site due to its susceptibility to wind erosion. 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 (2) occurs when invasive plant species invade adjacent native grassland communities. Introduced bluegrasses, such as Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*Poa compressa*), are a concern, particularly in the moister portions of this site (Adams et al., 2013). Crested wheatgrass also may be a concern on the drier portions of this site, particularly when native plant communities are adjacent to seeded pastures. 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 are not widespread in MLRA 52, but have the potential to invade this site if a seed source is present. 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 such as 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. This state can transition back to the Cropland State (4) if the site is put back into cultivation.

Phase 5.1: Abandoned Cropland Community Phase
The Abandoned Cropland Community Phase (5.1) can occurs when cropland is abandoned. 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, shortgrasses, and possibly prairie sandreed. 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 and the coarse soil textures. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses such as blue grama. Prairie sandreed is also known to be a pioneer species on sandy sites, although its abundance in MLRA 52 has not been fully studied. Depending on the historical management of the site, perennial bunchgrasses such as needle and thread may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species, such as Kentucky bluegrass or crested wheatgrass, 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
The Perennial Grass Community Phase (5.2) occurs when the site is seeded to perennial forage species. This community phase can persist for several decades, particularly introduced perennial grasses are seeded. Some introduced species, such as crested wheatgrass, 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 to cropland.

State and transition model

Sandy Moist Grassland
R52XY747MT

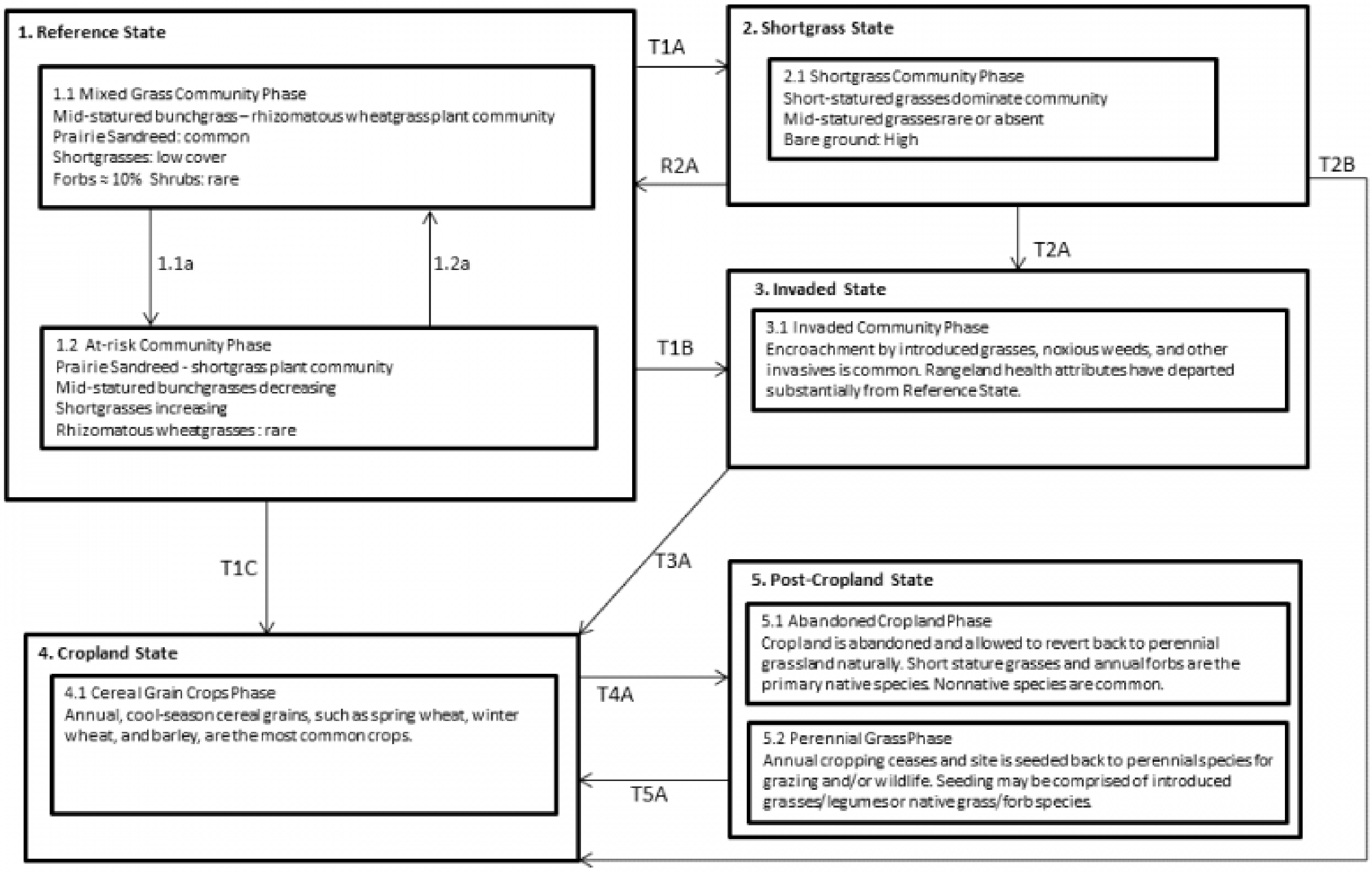

Figure 2. State-and-transition diagram

Sandy Moist Grassland
R52XY747MT

Legend

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

Inventory data references

No field data was available for this provisional ecological site. Professional experience and a review of the scientific literature, was used to approximate the reference plant community. Representative long-term data from the Many Island Lake and Turin rangeland reference areas in Alberta, Canada were used to estimate total annual production (Broadbent et al., 2013). 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

Adams, B.W., et al. 2013. Rangeland plant communities for the mixedgrass natural subregion of Alberta. Second approximation. Rangeland Management Branch, Policy Division, Alberta Environment and Sustainable Resource Development, Lethbridge, Pub. No. T/039.

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

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

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

Biondini, M.E., B.D. Patton, and P.E. Nyren. 1998. Grazing intensity and ecosystem processes in a northern mixed-grass prairie, USA. Ecological Applications 8:469-479.

Bloom-Cornelius, I.V. 2011. Vegetation response to fire and domestic and native ungulate herbivory in a Wyoming big sagebrush ecosystem. M.S. thesis, Oklahoma State University. Stillwater, OK.

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

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

Broadbent, T., L. Blonski, D. Moisey, and C. DeMaere. 2013. Dry Mixedgrass, Mixedgrass, and Foothills Fescue Annual Report. Alberta Environment and Sustainable Resource Development. Grassland Range Reference Area Program. Lethbridge, Alberta, Canada.

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

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

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

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

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

Cooper, S.V., and W.M. Jones. 2003. Site descriptions of high-quality wetlands derived from existing literature sources. Report to the Montana Department of Environmental Quality. Montana Natural Heritage Program, Helena, MT.

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

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

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

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

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. US Fish and Wildlife Service FWS/OBS, 79(31), 131.

Crowe, E., and G. Kudray. 2003. Wetland Assessment of the Whitewater Watershed. Report to U.S. Bureau of Land Management, Malta Field Office. Montana Natural Heritage Program, Helena, MT.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Galatowitsch, S.M., and A.G. Van der Valk. 1996. The vegetation of restored and natural prairie wetlands. Ecological Applications. 6:1 pp.102-112.

Gilbert, M.C., P.M. Whited, E.J. Clairain Jr., and R.D. Smith. 2006. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of prairie potholes. U.S. Army Corps of Engineers Final Report, Washington, DC.

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

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

Hansen, P.L., et al. 1995. Classification and management of Montana's riparian and wetland sites. University of Montana, Montana Forest and Conservation Experiment Station, Miscellaneous Publication No. 54.

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

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

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

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

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

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

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

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

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

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

Howard, J.L. 1999. Artemisia tridentata subsp. wyomingensis. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service http://www.fs.fed.us/database/feis/plants/shrub/arttriw/all.html accessed (8/11/2016).

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

Jones, W.M. 2004. Using vegetation to assess wetland condition: a multimetric approach for temporarily and seasonally flooded depressional wetlands and herbaceous-dominated intermittent and ephemeral riverine wetlands in the northwestern glaciated plains ecoregion, Montana. Report to the Montana Department of Environmental Quality and the U.S. Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT.

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

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

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

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

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

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

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

Lesica, P., and P. Husby. 2006. Field Guide to Montana's Wetland Vascular Plants. Montana Wetlands Trust. Helena, MT.

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

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

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

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

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

McIntyre, C., K. Newlon, L. Vance, and M. Burns. 2011. Milk, Marias, and St. Mary monitoring: developing a long-term rotating basin wetland assessment and monitoring strategy for Montana. Report to the United States Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Smith, R.E. 2013. Conserving Montana's sagebrush highway: Long distance migration in sage-grouse. M.S. thesis, University of Montana, Missoula, MT.

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

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

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

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

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

Stephens, S.E., J.J. Rotella, M.S. Lindberg, M.L. Taper, and J.K. Ringelman. 2005. Duck nest survival in the

Missouri Coteau of North Dakota: Landscape effects at multiple spatial scales. Ecological Applications 15:2137-2149.

Stewart, R.E., and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. No. 92. US Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.

Tiner, R.W. 2003. Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Region 5, Hadley, MA.
http://www.fws.gov/northeast/wetlands/pdf/CorrelatingEnhancedNWIDataWetlandFunctions WatershedAssessments[1].pdf.

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

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

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

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

Vance, L., S. Owen, and J. Horton. 2013. Literature review: Hydrology-ecology relationships in Montana prairie wetlands and intermittent/ephemeral streams. Report to the Cadmus Group and the U.S. Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT.

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

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

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

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

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

Wambolt, C.L., K.S. Walhof, and M.R. Frisina. 2001. Recovery of big sagebrush communities after burning in south-western Montana. Journal of Environmental Management. 61:243-252.

Watts, M.J., and C.L. Wambolt. 1996. Long-term recovery of Wyoming big sagebrush after four treatments. Journal of Environmental Management 46:95-102.

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

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

With, K.A. 2010. McCown's longspur (Rhynchophanes mccownii). In: A. Poole (ed.) The Birds of North America (online), Cornell Lab of Ornithology, Ithaca. http://bna.birds.cornell.edu/bna/species/09.

Contributors

Scott Brady
Stuart Veith

Approval

Scott Brady, 8/27/2019

Acknowledgments

This provisional ecological site description could not have been completed without the contributions of Karen Newlon. She conducted an extensive literature review, which provided most of the background information for this project as well as many of the references. She also co-authored the Loamy and Thin Claypan Dry Grassland ecological sites previously prepared in MLRA 52.

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

Soil Concepts, Soils Information, and Field Descriptions
Charlie French, USDA-NRCS
Josh Sorlie, USDI-BLM

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

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:**

---

17. **Perennial plant reproductive capability:**
