Ecological site FX052X02X021
Sandy Gravel (Sygr) 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: *Hesperostipa comata* – *Bouteloua gracilis* Dry Mixedgrass Prairie Group (2.B.2.Nb.2.b)
• Alliance: *Pseudoroegneria spicata* – *Pascopyrum smithii* – *Hesperostipa comata* Grassland Alliance
• Association: No existing correlation

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 Gravel 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. It occurs on outwash fans, alluvial fans, and terraces where sand and gravel have been deposited. This site can be found on any slope or slope shape.

The distinguishing characteristic of this site is that the upper 20 inches of soil is predominantly sandy skeletal, meaning that it contains 35 percent or more coarse fragments and has a texture class of loamy fine sand or coarser (Soil Survey Staff, 2014). Soils for this ecological site are typically deep to very deep (more than 40 inches) and derived primarily from alluvium or glacial outwash. Soil textures in the upper 4 inches are typically very gravelly sandy loam or very gravelly loam, but soils may also have a loamy surface over sandy-skeletal material in some cases. Slopes are highly variable and may range from 0 to 60 percent. Characteristic vegetation is mid-statured, cool-season bunchgrasses and rhizomatous wheatgrasses.

Associated sites

FX052X02X062	**Swale (Se) Moist Grassland** This site is generally found downslope from the Sandy Gravel Moist Grassland ecological site in swales and drainageways. It also receives additional moisture from surface water run in.
FX052X02X110	**Sandy (Sy) Moist Grassland** This site occurs adjacent to the Sandy Gravel Moist Grassland ecological site on similar landforms. It generally occurs in the same slope positions as the Sandy Gravel Moist Grassland ecological site, but where coarse fragment content is less than 35 percent.
FX052X02X022	**Loamy Gravel (Logr) Moist Grassland** This site occurs on similar landscapes and slope positions as the Sandy Gravel Moist Grassland ecological site. It is adjacent to Sandy Gravel Moist Grassland ecological site, but occurs where fine-earth textures are coarse sandy loam or finer.

Similar sites

FX052X02X022	**Loamy Gravel (Logr) Moist Grassland** This site differs from the Sandy Gravel Moist Grassland ecological site in that its soils are loamy skeletal rather than sandy skeletal, meaning that fine-earth textures are coarse sandy loam or finer. Percent clay in the fine-earth fraction is typically 18 to 35 percent.
FX052X02X110	**Sandy (Sy) Moist Grassland** This site differs from the Sandy Gravel Moist Grassland ecological site in that its soils are sandy skeletal rather than loamy skeletal, meaning that fine-earth textures are loamy fine sand or coarser. Percent clay in the fine-earth fraction is typically less than 18 percent.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY748MT

Physiographic features

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

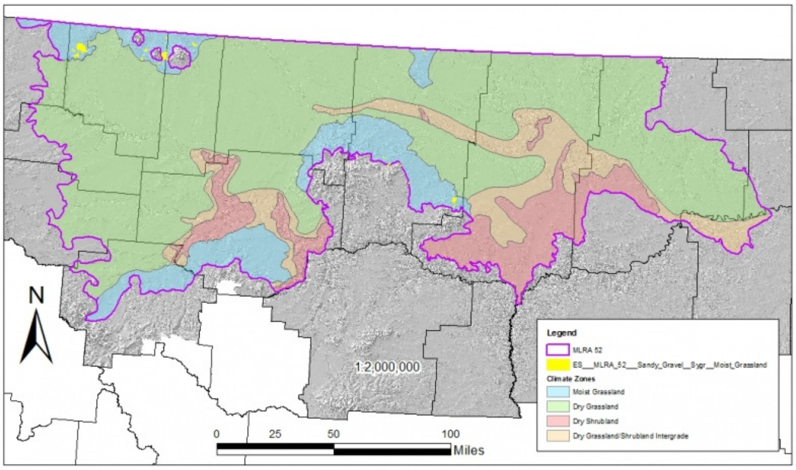


Figure 1. Figure 1. General distribution of the Sandy Gravel Moist Grassland ecological site by map unit extent.

Table 2. Representative physiographic features

Landforms	(1) Outwash fan (2) Alluvial fan (3) Terrace
Elevation	1,097–1,399 m
Slope	0–60%
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)	381 mm

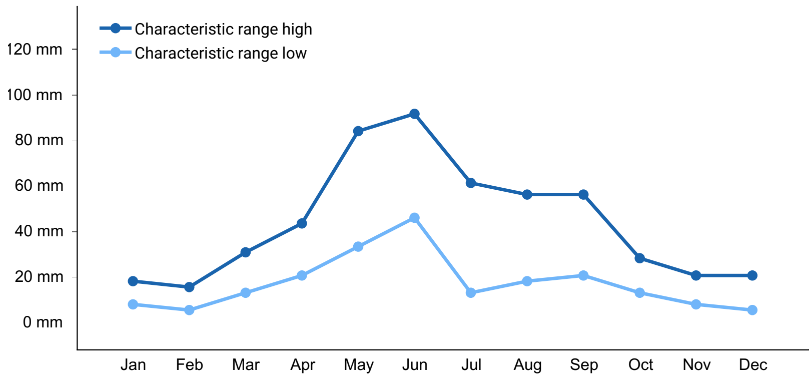


Figure 2. Monthly precipitation range

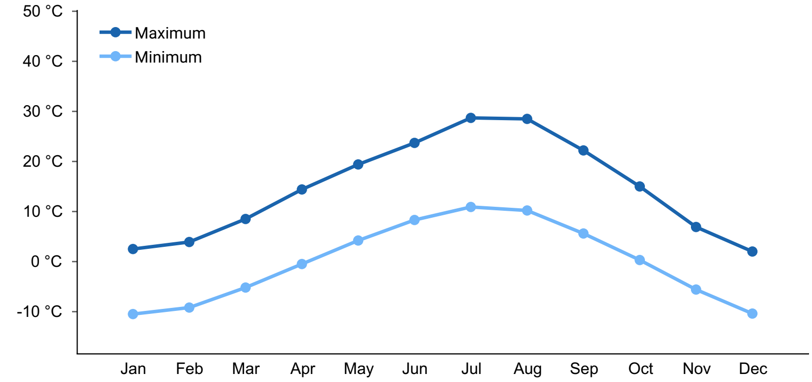


Figure 3. Monthly average minimum and maximum temperature

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 that normally functions as a recharge site, particularly in the spring. The high content of coarse fragments and sand results with a very high infiltration rate. During peak precipitation periods, typically May and June, this site delivers moisture to downslope sites via subsurface flow. During intense precipitation events, the site may also deliver moisture to downslope sites via surface runoff. For the remainder of the year moisture loss exceeds precipitation and this ecological site is in a state of moisture deficit for the majority of the growing season. Soil moisture is the primary limiting factor for plant production on this ecological site.

Soil features

The soil that is most representative of the central concept this ecological site is the Wabek series. This soil is in the Haplustolls great group. It is characterized by a mollic epipedon and by gravelly to very gravelly coarse sand in the underlying horizons. The particle-size family is sandy skeletal and the minerology is mixed. 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 most commonly range from gravelly loam to very gravelly sandy loam. However, some sites may have a loam surface horizon over very gravelly subsurface horizons. The underlying horizons contain 35 percent or more coarse fragments and have coarse sand, fine sand, or loamy sand textures. 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). Calcium carbonate equivalent varies from 0 to 15 percent. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH classes are neutral to slightly alkaline in the surface horizon and neutral to strongly alkaline in the subsurface horizons. The soil depth class for this site is typically deep to very deep (greater than 40 inches to bedrock).

Content of coarse fragments is 35 percent or more in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Alluvium (2) Glaciofluvial deposits
Surface texture	(1) Gravelly loam (2) Very gravelly sandy loam
Drainage class	Excessively drained
Soil depth	102–183 cm
Available water capacity (0-101.6cm)	4.45–6.1 cm
Calcium carbonate equivalent (0-12.7cm)	0–14%
Electrical conductivity (0-50.8cm)	0–3 mmhos/cm
Sodium adsorption ratio (0-50.8cm)	0–12
Soil reaction (1:1 water) (0-101.6cm)	6.6–9
Subsurface fragment volume <=3" (0-50.8cm)	35–89%
Subsurface fragment volume >3" (0-50.8cm)	35–89%

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 Gravel 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 species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). Due to the dominance of cool-season graminoids, annual production is highly dependent upon mid- to late-spring precipitation (Heitschmidt and Vermeire, 2005; Anderson, 2006).

Native grazers also shaped these plant communities. Bison (Bison bison) were the dominant historic grazer, but pronghorn (Antilocapra americana), elk (Cervus canadensis), and deer (Odocoileus spp.) were also common. Additionally, small mammals such as prairie dogs (Cynomys spp.) and ground squirrels (Urocitellus spp.) influenced this plant community (Salo et al., 2004). Grasshoppers and periodic outbreaks of Rocky Mountain locusts (Melanoplus spretus) also played an important role in the ecology of these communities (Lockwood, 2004).

The historic ecosystem experienced periodic lightning-caused fires with estimated fire return intervals of 6 to 25 years (Bragg, 1995). Historically, Native Americans also set periodic fires. The majority of lightning-caused fires occurred in July and August, whereas Native Americans typically set fires during spring and fall to correspond with the movement of bison (Higgins, 1986). Generally, the mixedgrass ecosystem is resilient to fire and the primary effects of the historic fire return interval are reduction of litter and short-term fluctuations in production (Vermeire et al., 2011, 2014). However, studies have shown that shorter fire return intervals can have a negative effect, shifting species composition toward warm-season, short-statured grasses (Shay et al., 2001; Smith and McDermid, 2014).

Improper grazing of this site can result in a reduction in the cover of the mid-statured bunchgrasses, a decrease in cool-season 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/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 crested wheatgrass (*Agropyron cristatum*), are the most likely invasive species. Seeding of introduced grasses, particularly crested wheatgrass, was a common practice on eroded and abandoned agricultural areas after the droughts of the 1930s (Rogler and Lorenz, 1983). Crested wheatgrass can invade relatively undisturbed grasslands, reducing cover and production of native cool-season midgrasses (Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Once established, invasive species will displace native species and dominate the ecological functions of the site.

Due to the very low water holding capacity, this ecological site is not generally regarded as productive cropland. Regardless, some acres have been cultivated and planted to cereal grain crops, such as winter wheat, spring wheat, and barley. When taken out of production, this site is either allowed to revert back to perennial grassland or is seeded back to perennial grass. Such seedings may be comprised of introduced grasses and legumes or a mix of native species. Sites left to undergo natural plant succession after cultivation can, over several decades, support native vegetation similar to the Reference State (1) (Christian and Wilson, 1999) although it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar and Willms, 1990). Sites seeded with non-native species may persist with this cover type indefinitely (Christian and Wilson, 1999). A mix of native species may also be seeded, however, a return to the Reference State (1) in a reasonable amount of time is unlikely.

The state-and-transition model (STM) diagram (Figure 2) suggests possible pathways that plant communities on this site may follow as a result of a given set of ecological processes and management. The site may also support states not displayed in the STM diagram. Landowners and land managers should seek guidance from local professionals before prescribing a particular management or treatment scenario. Plant community responses vary across this MLRA due to variability in weather, soils, and aspect. The reference community phase may not necessarily be the management goal. The lists of plant species and species composition values are provisional and are not intended to cover the full range of conditions, species, and responses for the site. Species composition by dry weight is provided when available and is considered provisional based on the sources identified in the narratives associated with each community phase.

State 1: Reference State
The Reference State (1) contains two community phases characterized by mid-statured bunchgrasses, and mid-statured rhizomatous wheatgrasses. This state evolved under the combined influences of climate, grazing, and fire with climatic variation having the greatest influence on cover and production. In general, this phase was resilient to grazing and fire, although these factors could influence species composition in localized areas.

Phase 1.1: Mixedgrass Community Phase
The Mixedgrass Community Phase (1.1) is characterized by mid-statured bunchgrasses and rhizomatous wheatgrasses. The predominant bunchgrass species are needle and thread (*Hesperostipa comata*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Rhizomatous wheatgrasses include both western wheatgrass (*Pascopyrum smithii*) and thickspike wheatgrass (*Elymus lanceolatus*), with thickspike wheatgrass becoming more abundant in the northern extent of this ecological site. Shortgrasses may include prairie Junegrass, blue grama, and Sandberg bluegrass (*Poa secunda*). Common forbs are spiny, or Hood's, phlox (*Phlox hoodii*), and Missouri goldenrod (*Solidago missouriensis*). Shrubs and subshrubs comprise up to 5 percent of canopy cover and typically include prairie sagewort (*Artemisia frigida*) and silver sagebrush (*Artemisia cana*). The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Mid-Statured Bunchgrasses 40%
Needle and Thread (10-35%)
Bluebunch Wheatgrass (5-30%)

Rhizomatous Wheatgrass 20%
Prairie Junegrass 10%
Other Native Grasses 15%
Perennial Forbs 10%
Shrubs/Subshrubs 5%

Estimated Total Annual Production (lbs/ac)*
Low - Insufficient data
Representative Value - 900
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. Multiple fires in close succession can also transition the site to this phase. It is characterized by nearly equal proportions of shortgrasses and needle and thread. Rhizomatous wheatgrasses have been substantially reduced in both cover and vigor and are rare. Other mid-statured bunchgrass species such as bluebunch wheatgrass are rare or absent, particularly in spring grazed pastures. Shortgrasses such as prairie Junegrass and blue grama are increasing. Prairie sagewort may also increase in this phase.

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

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). Crested wheatgrass is a potential concern, particularly when native plant communities are adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. 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 needle and thread, bluebunch wheatgrass, and rhizomatous wheatgrasses have been largely eliminated. Short-statured species such as prairie Junegrass, blue grama, and Sandberg bluegrass dominate the plant community. The subshrub, prairie sagewort is common.

Transition T2A
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). Crested wheatgrass is a potential concern, particularly when native plant communities are adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference State (1).

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

Restoration Pathway R2A
A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of shortgrasses in the Shortgrass State (2) (Dormaar and Willms, 1990). Blue grama in particular, can resist displacement by other species (Dormaar and Willms, 1990; Laycock, 1991; Dormaar et al., 1994; Lacey et al., 1995). Intensive management such as reseeding and mechanical treatment may be necessary (Hart et al., 1985), but these practices are labor intensive and costly. Therefore, returning the Shortgrass State (2) to the Reference State (1) can require considerable energy and cost and may not be feasible within a reasonable amount of time.

State 3: Invaded State
The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Crested wheatgrass is a potential concern, especially when native plant communities are adjacent to seeded pastures. An estimated 20 million acres of crested wheatgrass have been planted in the western U.S. (Holechek, 1981). Crested wheatgrass produces abundant seeds that can dominate the seedbank of invaded grasslands (Henderson and Naeth, 2005), although crested wheatgrass cover decreases with increasing distance from seeded areas (Heidinga and Wilson, 2002). Introduced bluegrasses, such as Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*Poa compressa*) may establish on sites with slightly more moisture, but this possibility has not been studied and requires further investigation. 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 in the absence of active management. The site can re-vegetate naturally and, over time, potentially return to a perennial grass community with bunchgrasses and blue grama. Shortly after cropland is abandoned, annual and biennial forbs and annual brome grasses invade the site (Samuel and Hart, 1994). The site is extremely susceptible to erosion due to the absence of perennial species. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses, such as blue grama. Depending on the historical management of the site, perennial bunchgrasses such as needle and thread may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species 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 when seeded to introduced perennial grasses. 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

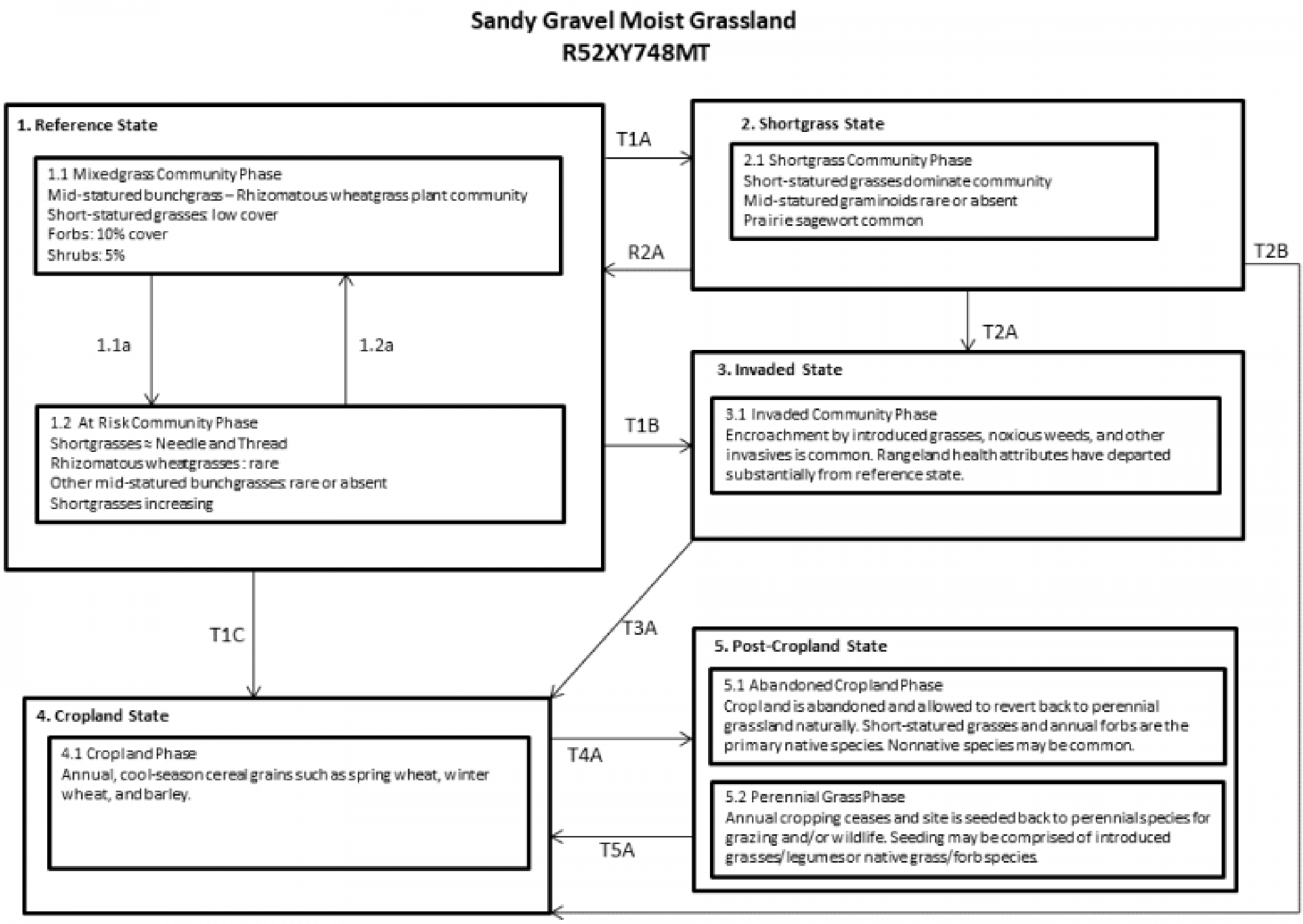
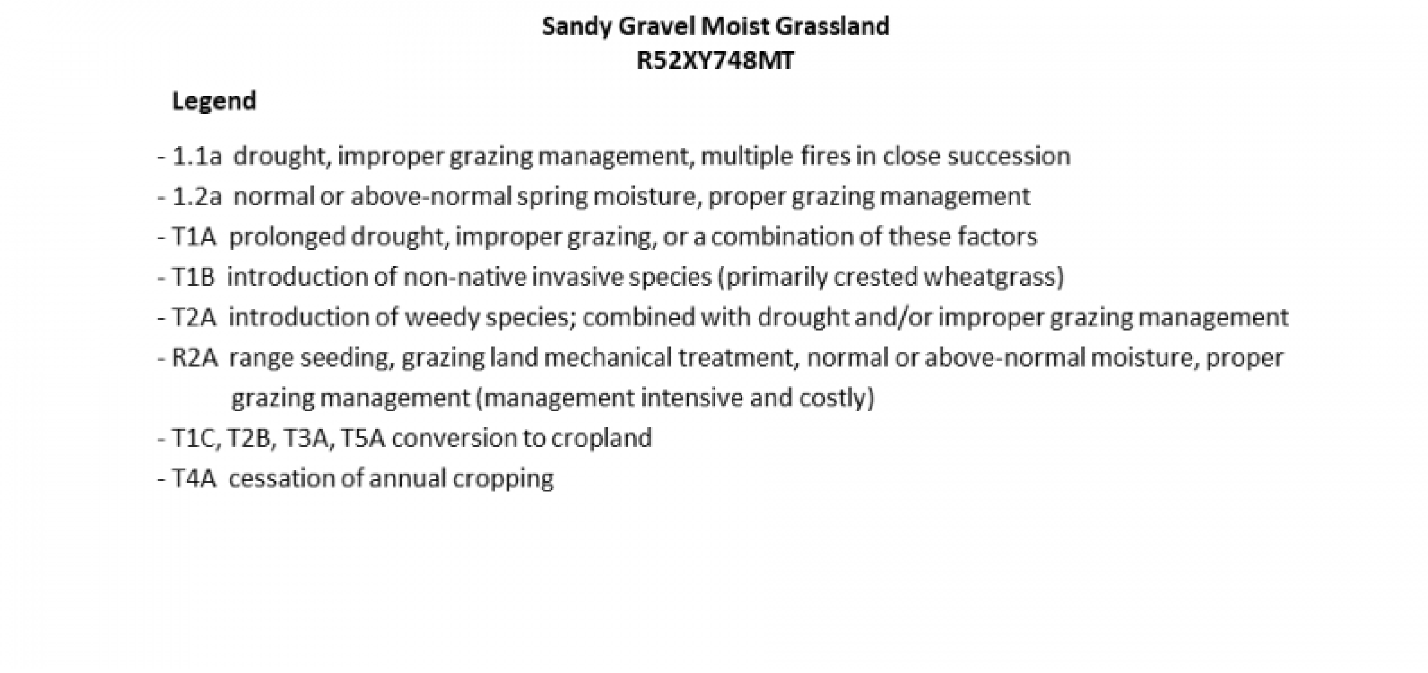


Figure 2. State-and-transition diagram



Inventory data references

No field data was available for this provisional ecological site. One medium-intensity plot from the Sandy Gravel Dry Shrubland ecological site was determined to be a close approximation and was used as a reference. This plot, in combination with professional experience and a review of the scientific literature, was used 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.

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Approval

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Rangeland health reference sheet

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

Author(s)/participant(s)	
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):**

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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):**

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

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17. **Perennial plant reproductive capability:**
