Ecological site FX052X01X021
Sandy Gravel (Sygr) Dry 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 and agriculturally and ecologically significant area. It consists of around 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 sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007) 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 zone represents the northernmost extent of the big sagebrush (Artemisia tridentata) steppe on the Great Plains. As 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 in the fact that 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: Dry 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) and Glaciated Northern Grasslands (42j)

Ecological site concept

This provisional ecological site occurs in the Dry 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 Dry Grassland is an ecological site of limited extent occurring on most landscapes throughout MLRA 52. It occurs on outwash fans, terraces, and kames 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 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 from sandy and gravelly glaciofluvial or Tertiary alluvial deposits. 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. The principal shrub on this site is silver sagebrush (*Artemisia cana*), which typically comprises 5 percent of the cover or less.

Associated sites

FX052X01X032	**Loamy (Lo) Dry Grassland** Loamy Dry Grassland is on similar landscapes and slope positions as the Sandy Gravel Dry Grassland. It is adjacent to Sandy Gravel Dry Grassland where slopes are less than 15 percent and coarse fragment content is less than 35 percent.
FX052X01X110	**Sandy (Sy) Dry Grassland** Sandy Dry Grassland is on similar landscapes and slope positions as the Sandy Gravel Dry Grassland. It is adjacent to Sandy Gravel Dry Grassland where coarse fragment content is less than 35 percent.
FX052X01X022	**Loamy Gravel (Logr) Dry Grassland** Loamy Gravel Dry Grassland is on similar landscapes and slope positions as the Sandy Gravel Dry Grassland. It is adjacent to Sandy Gravel Dry Grassland where fine-earth textures are coarse sandy loam or finer.
FX052X01X062	**Swale (Se) Dry Grassland** Swale Dry Grassland is found downslope from Sandy Gravel Dry Grassland. It is on similar landscapes but in swales that receive additional moisture.

Similar sites

FX052X03X021	**Sandy Gravel (Sygr) Dry Shrubland** This site differs from Sandy Gravel Dry Grassland in that it has slightly warmer annual temperatures and can support Wyoming big sagebrush.
FX052X01X022	**Loamy Gravel (Logr) Dry Grassland** This site differs from Sandy Gravel Dry Grassland 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.
FX052X01X110	**Sandy (Sy) Dry Grassland** This site differs from Sandy Gravel Dry Grassland in that is contains less than 35 percent coarse fragments; whereas, the Sandy Gravel Dry Grassland contains 35 percent or more coarse fragments. Vegetation contains a significant proportion of warm-season rhizomatous grasses.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY021MT

Physiographic features

Sandy Gravel Dry Grassland is an ecological site of limited extent in MLRA 52 occurring on outwash fans, terraces, and kames where sand and gravel have been deposited.

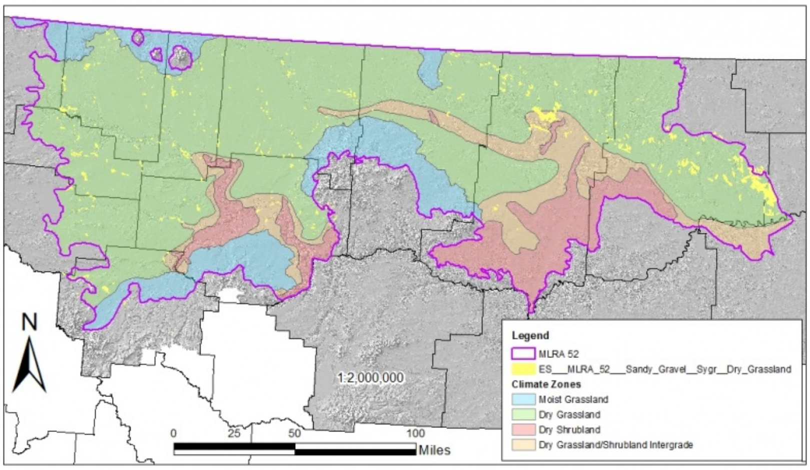

Figure 1. Figure 1. General distribution of the Sandy Gravel Dry Grassland ecological site by map unit extent

Table 2. Representative physiographic features

Landforms	(1) Till plain > Kame (2) Till plain > Outwash fan (3) Terrace
Elevation	2,000–3,870 ft
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 120 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 ten years. Annual precipitation ranges from 10 to 14 inches, and 70 to 80 percent of this 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 the reaction of plants to a “false spring” (Oard, 1993).

Table 3. Representative climatic features

Frost-free period (average)	120 days
Freeze-free period (average)	140 days
Precipitation total (average)	12 in

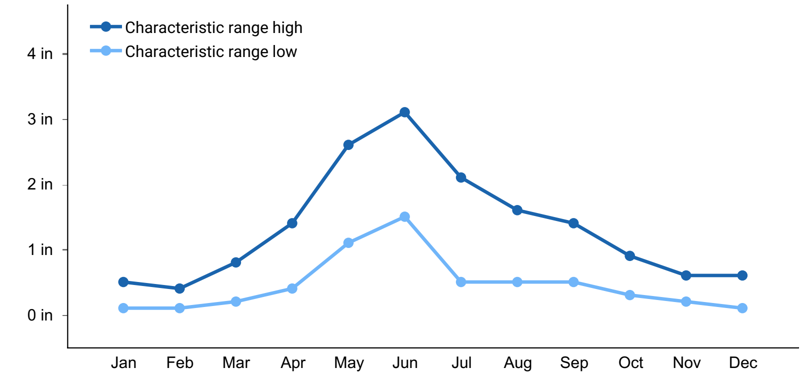

Figure 2. Monthly precipitation range

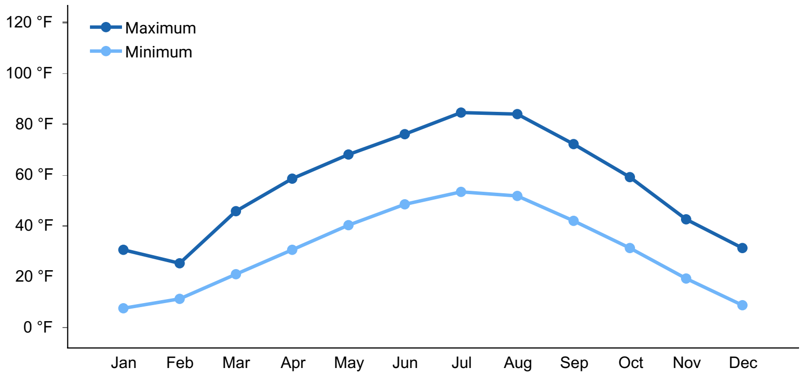

Figure 3. Monthly average minimum and maximum temperature

Climate stations used

- (1) TIBER DAM [USC00248233], Chester, MT
- (2) MALTA 7 E [USC00245338], Malta, MT
- (3) TURNER 11N [USC00248415], Turner, MT
- (4) CONRAD [USC00241974], Conrad, MT
- (5) SHELBY [USC00247500], Shelby, MT
- (6) GLASGOW [USW00094008], Glasgow, MT
- (7) HAVRE CITY CO AP [USW00094012], Havre, MT
- (8) CARTER 14 W [USC00241525], Floweree, MT
- (9) CHESTER [USC00241692], Chester, MT
- (10) HARLEM [USC00243929], Harlem, MT

Influencing water features

This is a recharge upland ecological site. The high content of coarse fragments and sand results with a very high infiltration rate and 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. Recharge peaks in May and June and moisture loss exceeds precipitation 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 series that best represents the central concept for this ecological site are the Wabek soil and the Tinsley soil. The Sandy Gravel ecological site concept covers approximately 44,000 acres in MLRA 52. The Wabek 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 Tinsley soil is in the Ustorthents great group. It lacks enough organic matter to have a mollic epipedon. Its underlying horizons are characterized by very gravelly to extremely gravelly loamy sand. The particle-size family for both soils is sandy skeletal and the minerology is mixed. The typical parent materials for these series are gravelly glaciofluvial deposits. The soil moisture regime for these and all other soils in this ecological site concept is ustic bordering on aridic, 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. 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 0.5 to 3 percent, and moist colors vary from dark yellowish brown (10YR 4/4) to very dark grayish brown (10YR 3/2). Calcium carbonate equivalent varies from 0 to 15 percent. In the surface 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) Glaciofluvial deposits
Surface texture	(1) Gravelly loam (2) Very gravelly sandy loam
Drainage class	Excessively drained
Soil depth	40–72 in
Available water capacity (0-40in)	1–2.4 in
Calcium carbonate equivalent (0-5in)	0–14%
Electrical conductivity (0-20in)	0–3 mmhos/cm
Sodium adsorption ratio (0-20in)	0–12
Soil reaction (1:1 water) (0-40in)	6.6–9
Subsurface fragment volume <=3" (0-20in)	35–89%
Subsurface fragment volume >3" (0-20in)	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 Dry Grassland provisional ecological site in MLRA 52 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 the Sandy Gravel Dry Grassland ecological site evolved under the combined influences of climate, grazing, and fire. Extreme climatic variability results in frequent droughts, which have the greatest influence on the relative contribution of species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). Due to the dominance of cool-season graminoids, annual production is highly dependent upon mid- to late-spring precipitation (Heitschmidt and Vermeire, 2005; Anderson, 2006).

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

The historic ecosystem also experienced relatively frequent lightning-caused fires with estimated fire return intervals of 6 to 25 years (Bragg, 1995). Historically, Native Americans also set periodic fires. The majority of lightning-caused fires occurred in July and August, whereas Native Americans typically set fires during spring and fall to correspond with the movement of bison (Higgins, 1986). Generally, the mixedgrass ecosystem is resilient to fire and the primary effects of fire under the historic fire regime 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). Conversely, long-term fire suppression in the 20th century removed periodic fire from the ecosystem altogether. Lack of periodic fires can result in an increase in litter accumulation, which in some cases provides ideal conditions for seed germination and seedling establishment of non-native annual brome species, such as field brome or Japanese brome (*Bromus arvensis*) (Whisenant, 1990). These species have become naturalized in relatively undisturbed grasslands (Ogle et al., 2003; Harmoney, 2007) and can be present in any state within the scope of this ecological site. They typically do not have a significant ecological impact; however, their presence can reduce the production of cool-season perennial grasses in some cases (Haferkamp et al., 1997). Their abundance varies depending on precipitation and germination conditions.

Improper grazing of this site can result in a reduction in the cover of the mid-statured 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 can reduce mid-statured bunchgrasses and cool-season, rhizomatous wheatgrasses, triggering an increase in shortgrasses such as blue grama and prairie Junegrass (Coupland, 1961).

Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as blue grama (*Bouteloua gracilis*) and prairie Junegrass (*Koeleria macrantha*). The cover of mid-statured rhizomatous grasses and bunchgrasses is severely reduced or absent. The cover of prairie, or fringed, sagewort (*Artemisia frigida*) can also increase.

Due to the very low water holding capacity, this ecological site is not generally regarded as productive cropland. Regardless, many acres have been cultivated and planted to cereal grain crops, such as winter wheat, spring wheat, and barley. When this site is taken out of production, the site is either allowed to revert back to perennial grassland or is seeded with perennial species. Seeding of introduced grasses, particularly crested wheatgrass (*Agropyron cristatum*), was a common practice on eroded and abandoned agricultural areas after the droughts of the 1930s (Rogler and Lorenz, 1983). Crested wheatgrass is a highly drought tolerant and competitive cool-season, perennial bunchgrass (DeLuca and Lesica, 1986). Crested wheatgrass can invade relatively undisturbed grasslands, reducing cover and production of native cool-season midgrasses (Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Sites seeded with non-native species, particularly crested wheatgrass may persist as this cover type indefinitely (Christian and Wilson, 1999). The site may also be seeded to native species which provides species composition and structural complexity similar to that of the Reference State (1). However, it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar and Willms, 1990). Sites left to undergo natural plant succession after cultivation can, over several decades, support native vegetation similar to the Reference State (1), however, soil quality is consistently lower than under conditions prior to cultivation (Dormaar and Smoliak, 1985).

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. This state evolved under the combined influences of climate, grazing, and fire with climatic variation having the greatest influence on cover and production. In general, this phase was resilient to grazing and fire, although these factors could influence species composition in localized areas. Vegetation is characterized by mid-statured cool-season bunchgrasses, mid-statured cool-season rhizomatous grasses, and short statured grasses. Dense clubmoss may or may not be present in this state. The dynamics of this species are not well understood and its abundance may vary greatly from site to site without discernable reason.

Phase 1.1 Mixedgrass Community Phase
The Mixedgrass Community Phase (1.1) is typically dominated by mid-statured cool-season bunchgrasses, which typically comprise about 45 percent of the total production. Needle and thread (*Hesperostipa comata*) is the most common bunchgrass, but other species that may occur on this site are plains muhly (*Muhlenbergia cuspidata*) and bluebunch wheatgrass (*Pseudoroegneria spicata*). Western wheatgrass (*Pascopyrum smithii*) is the predominant rhizomatous wheatgrass although thickspike wheatgrass (*Elymus lanceolatus*) may also be present, particularly in the northern extent of this ecological site. Short-statured grasses, such as prairie Junegrass and blue grama are not abundant in this phase, but are generally present at low cover. Sedges (Carex spp.) may also be present at low cover. Common forbs are spiny, or Hood's, phlox (*Phlox hoodii*), and Indian breadroot, also known as scurfpea (Pediomelum spp). Shrubs and subshrubs comprise up to 5 percent of canopy cover. Silver sagebrush (*Artemisia cana*) and fringed sagewort are the most common species. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Needle and Thread 20-40%
Bluebunch Wheatgrass 0-20%
Plains Muhly 5%
Rhizomatous Wheatgrass 15%
Blue Grama 10%
Other Native Grasses 15%
Perennial Forbs 10%
Shrubs/Subshrubs 5%

Estimated Total Annual Production (lbs/ac)*
Low - 400
Representative Value - 600
High - 800
* Estimated based on current observation – subject to revision

Phase 1.2: At Risk Community Phase
In the At Risk Community Phase (1.2), needle and thread is in nearly equal proportion to shortgrasses. Other mid-statured bunchgrasses have been nearly eliminated. Rhizomatous wheatgrasses are in decline and are rare in this phase. Shortgrasses, such as blue grama, and prairie Junegrass, are increasing. Prairie sagewort may also increase in this phase.

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

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

Transition T1A
Improper grazing practices, prolonged drought (approximately 3 years or more), or a combination of these factors weaken the resilience of the Reference State (1) and drive its transition to the Shortgrass State (2). The Reference State (1) transitions to the Shortgrass State (2) when cool-season midgrasses become rare and contribute little to production. Shortgrasses, particularly prairie Junegrass, and the warm-season, mat-forming blue grama 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 common 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 (Henderson and Naeth, 2005) and soil quality (Smoliak and Dormaar, 1985; Dormaar et al., 1995), have been substantially altered from the Reference State.

Transition T1C
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, 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. The site is dominated by shortgrasses such as blue grama and prairie Junegrass. Mid-statured grasses, such as western wheatgrass, needle and thread, and bluebunch wheatgrass, have been eliminated or nearly so. Dense clubmoss may or may not be present in this state. The dynamics of this species are not well understood and its abundance may vary greatly from site to site without discernable reason.

Phase 2.1: Shortgrass Community Phase
In the Shortgrass Community Phase (2.1), mid-statured grasses have been largely eliminated and replaced by short-statured species, such as blue grama, and prairie Junegrass. Blue grama resists grazing due to its low stature and extensive root system. Once established, blue grama-dominated communities can alter soil properties, creating conditions that resist establishment of other grass species (Dormaar and Willms, 1990; Dormaar et al., 1994). Prairie sagewort is also common in this phase.

Transition T2A
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). Crested wheatgrass is a common 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 (Henderson and Naeth, 2005) and soil quality (Smoliak and Dormaar, 1985; Dormaar et al., 1995), have been substantially altered from the Reference State.

Transition T2B
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Invaded State (3) to the Cropland State (4).

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

State 3: Invaded State
The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Crested wheatgrass is a common concern, especially when native plant communities are adjacent to seeded pastures. An estimated 20 million acres of crested wheatgrass have been planted in the western U.S. (Holechek, 1981). Crested wheatgrass produces abundant seeds that can dominate the seedbank of invaded grasslands (Henderson and Naeth, 2005), although crested wheatgrass cover decreases with increasing distance from seeded areas (Heidinga and Wilson, 2002). The early growth of crested wheatgrass allows this species to take advantage of early season soil moisture, which may result in competitive exclusion of native cool-season rhizomatous wheatgrasses and bunchgrasses, such as needle and thread and prairie Junegrass (Christian and Wilson, 1999; Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Reduced soil quality (Dormaar et al., 1995), reduced plant species diversity,

and simplified structural complexity (Henderson and Naeth, 2005) result in a state that is substantially departed from the Reference State (1).

Noxious weeds such as leafy spurge are uncommon on this site, but are capable of invading if a seed source is present. These species are very aggressive. They typically displace native species and dominate ecological function when they invade a site. Sometimes, these species can be suppressed through intensive management (herbicide application, biological control, or intensive grazing management). Control efforts are unlikely to eliminate noxious weeds, but their density can be sufficiently suppressed so that species composition and structural complexity are similar to that of the Reference State (1). However, cessation of control methods will most likely result in recolonization of the site by the noxious species.

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

State 4: Cropland State
The Cropland State (4) occurs when land is put into cultivation. Major crops in MLRA 52 include winter wheat, spring wheat, and barley. On the sandy gravel ecological site, this state typically occurs on slopes less than 8 percent.

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
In the absence of active management, the site can re-vegetate naturally and, over time, potentially return to a perennial grassland community with needle and thread and blue grama. Shortly after cropland is abandoned, annual and biennial forbs and annual brome grasses invade the site (Samuel and Hart, 1994). The site is highly susceptible to erosion due to the absence of perennial species. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses. Depending on the historical management of the site, perennial bunchgrasses may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species, such as crested wheatgrass and annual bromes, will depend upon the site’s proximity to a seed source.

Fifty or more years after cultivation, these sites may have species composition similar to phases in the Reference State (1). However, soil quality is consistently lower than under conditions prior to cultivation (Dormaar and Smoliak, 1985; Christian and Wilson, 1999), and a shift to the Reference State (1) is unlikely within a reasonable timeframe.

Phase 5.2: Perennial Grass Community Phase
When the site is seeded to perennial forage species, particularly introduced perennial grasses, this community phase can persist for several decades. Crested wheatgrass, in particular, is very aggressive and may form monocultures that persist for at least 60 years (Krzic et al., 2000; Henderson and Naeth, 2005). A mixture of native species may also be seeded to provide species composition and structural complexity similar to those of the contemporary Reference State (1). However, soil quality conditions have been substantially altered and are unlikely to return to pre-cultivation conditions within a reasonable timeframe (Dormaar et al., 1994).

Transition 5A
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Post-Cropland State (5) back to the Cropland State (4).

State and transition model

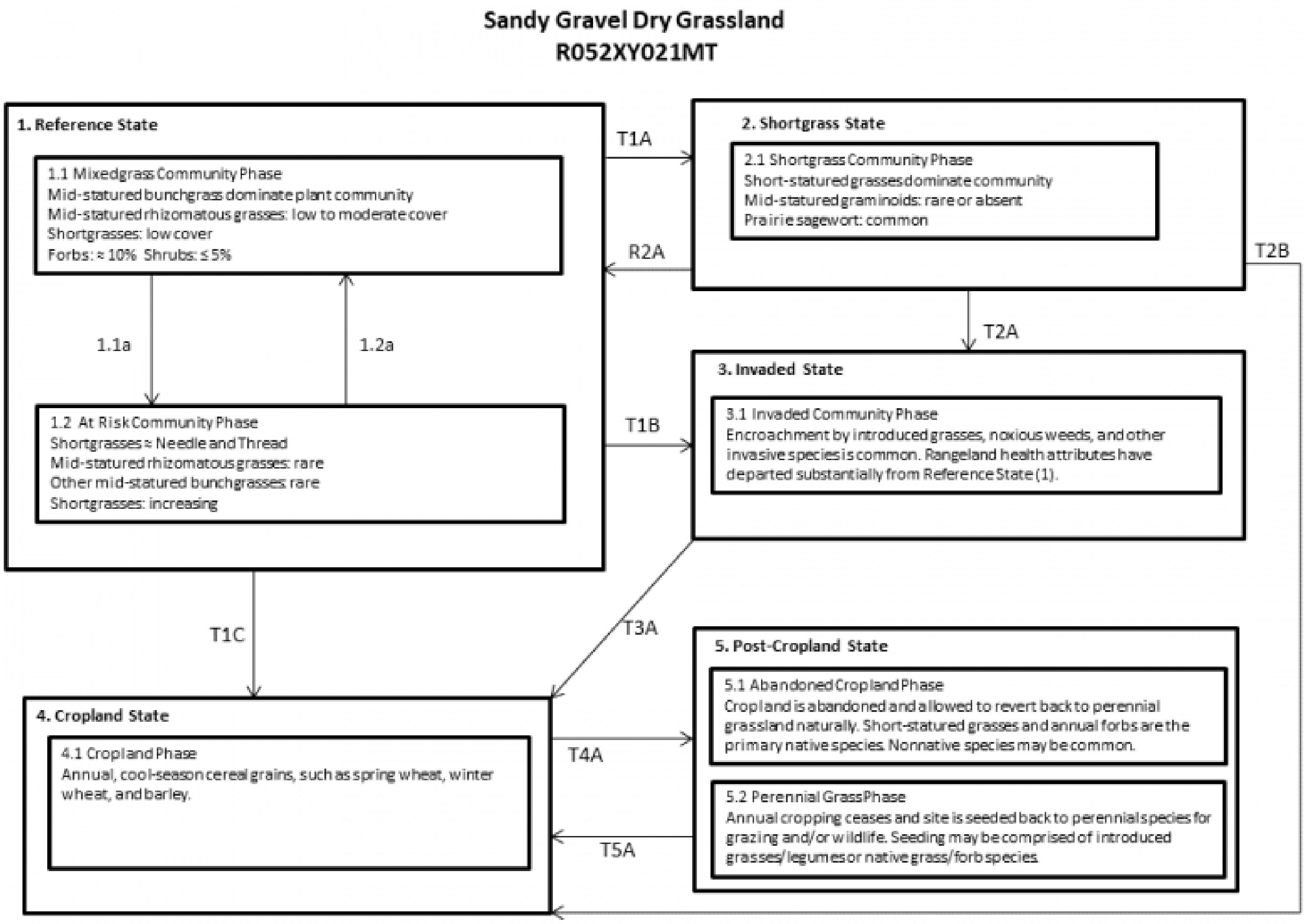

Figure 2. State-and-transition model (STM) diagram.

Sandy Gravel Dry Grassland
R052XY021MT

Legend

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

Figure 2 (continued).

Inventory data references

One medium-intensity plot and one historical (417) plot were available for this provisional ecological site. Historical plot data was used cautiously due to the fact that soils were not confirmed and the plot was located in an undetailed, high order soil map unit. These plots, in combination with professional experience and a review of the scientific literature, were used to approximate the reference plant community. Information for other states and community phases was obtained from a review of the scientific literature and professional experience. All community phases are considered provisional based on these plots and the sources identified in this ecological site description.

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Contributors

Scott Brady
Stuart Veith

Approval

Kirt Walstad, 12/28/2022

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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	05/12/2025

Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

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):**

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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:**
