

Ecological site FX052X03X110 Sandy (Sy) Dry Shrubland

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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.

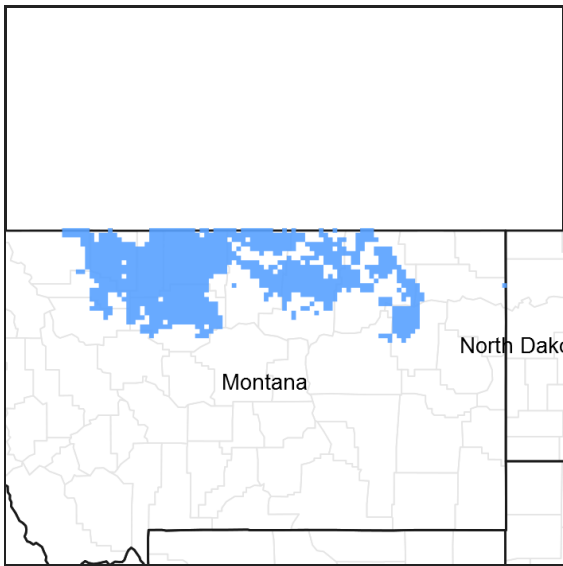


Figure 1. Mapped extent

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 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, with the maximum glacial extent occurring 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 the 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 Illinoian 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. 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 yet fully understood.

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 Shrubland

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 and Shrubland Formation (2.B.2)
- Division: *Andropogon gerardii* - *Pascopyrum smithii* - *Bouteloua gracilis* 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: *Artemisia filifolia* / *Calamovilfa longifolia* - *Yucca glauca* Sand Shrubland Group (2.B.2.Nb.4.a)

- Alliance: *Yucca glauca* Prairie Scrub Alliance
- Association: *Yucca glauca* / *Calamovilfa longifolia* Shrub 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) and Glaciated Northern Grasslands (42j)

Ecological site concept

This provisional ecological site occurs in the Dry Shrubland 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. Sandy Dry Shrubland is a moderately extensive ecological site on till plain landscapes in MLRA 52. This ecological site occurs on kames, eskers, outwash fans, and terraces. Slopes are typically less than 25 percent but may be steeper in some areas. This site can occur on any slope shape or slope position.

The distinguishing characteristics of this site are coarse-loamy textures in the upper 4 inches of soil and a relatively undeveloped soil profile. Calcium carbonate (lime) concentration in the upper 5 inches of soil varies from 0 to 15 percent but is typically 5 percent or less. Soils are typically moderately deep to very deep (more than 20 inches to bedrock) and are primarily derived from glaciofluvial material or alluvium over glacial till. In dissected areas where bedrock is exposed this site can be formed in soft sandstone. Soils in some areas, but not all, have a mollic epipedon. Soil surface textures fall within the coarse-loamy textural family and have less than 18 percent clay and less than 70 percent sand. Underlying horizons commonly have a cambic horizon that exhibits minimal pedogenic development. Species composition is dominated by drought-tolerant plants with deep, extensive root systems. Production potential on this site is typically somewhat less than on a loamy soil due to the reduced available water-holding capacity (AWC). Characteristic vegetation is needle and thread (*Hesperostipa comata*), threadleaf sedge (*Carex filifolia*), prairie sandreed (*Calamovilfa longifolia*), and Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*).

Associated sites

FX052X03X032	Loamy (Lo) Dry Shrubland This site occurs adjacent to the Sandy Dry Shrubland ecological site. It generally occurs on similar landscape positions, but occupies areas with finer textured soils such as ground moraines rather than kames or eskers.
FX052X03X030	Limy (Ly) Dry Shrubland This site occurs adjacent to the Sandy Dry Shrubland ecological site on similar landscapes. It is generally in positions with a convex slope shape; and in areas of finer textured soils such as ground moraines rather than kames or eskers.
FX052X03X040	Loamy-Steep (Lostp) Dry Shrubland This site occurs on moderate to steeply sloping hillslopes adjacent to or downslope from the Sandy Dry Shrubland ecological site. It is generally in backslope positions with a linear or concave slope shape and in areas of finer textured soils.

Similar sites

FX052X03X032	Loamy (Lo) Dry Shrubland This site differs from the Sandy Dry Shrubland ecological site in that soils contain more than 18 percent clay in the upper 4 inches. Western wheatgrass is a predominant component of the plant community.
FX052X03X030	Limy (Ly) Dry Shrubland This site differs from the Sandy Dry Shrubland 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.

FX052X01X110	Sandy (Sy) Dry Grassland This site differs from the Sandy Dry Shrubland ecological site in that it has slightly cooler annual temperatures and supports silver sagebrush rather than big sagebrush.
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Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY721MT

Physiographic features

Sandy Dry Shrubland is an extensive ecological site occurring primarily in the southern portions of MLRA 52. The majority of MLRA 52 is covered by a broad till plain, and this ecological site largely occurs in areas where cracks in the continental ice sheet were filled with sand or areas of glacial outwash or along present-day streams or rivers. This site can occur on any slope or slope position on kames, eskers, outwash fans, and terraces. Slopes are typically less than 25 percent but may be as steep as 45 percent in some areas.

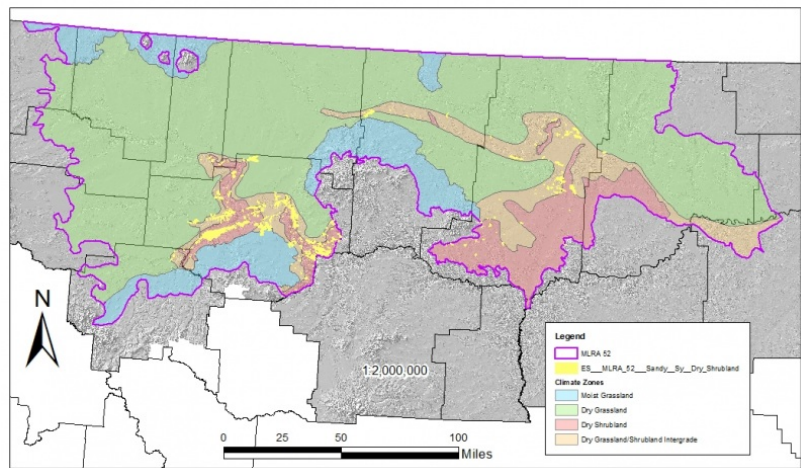


Figure 2. Figure 1. General distribution of the Sandy Dry Shrubland ecological site by map unit extent.

Table 2. Representative physiographic features

Landforms	(1) Till plain > Kame (2) Till plain > Esker (3) Till plain > Outwash fan (4) Terrace
Elevation	2,000–3,870 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 125 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 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 a reaction of plants to a “false spring” (Oard, 1993).

Table 3. Representative climatic features

Frost-free period (average)	125 days
Freeze-free period (average)	145 days
Precipitation total (average)	13 in

Climate stations used

- (1) CONTENT 3 SSE [USC00241984], Zortman, MT
- (2) FT BENTON [USC00243113], Fort Benton, MT
- (3) FT PECK PWR PLT [USC00243176], Fort Peck, MT
- (4) LOMA 1 WNW [USC00245153], Loma, MT
- (5) MALTA 7 E [USC00245338], Malta, MT
- (6) MALTA 35 S [USC00245340], Zortman, 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

Soils that best represent the central concept of this ecological site are Chinook, Fortbenton, and Busby. The Chinook and Fortbenton soils are in the Haplustolls great group. They have a relatively dark mollic epipedon and an underlying cambic horizon where pedogenic development is present but minimal. The Busby soil is in the Haplustepts great group. It also contains a cambic horizon but does not have a mollic epipedon. The Chinook and Busby soils are in the coarse-loamy family, while the Fortbenton soil is in the fine-loamy family. All three soils have mixed minerology. The soil moisture regime for these and all 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 in this site are typically sandy loam or fine sandy loam and contain less than 18 percent clay and less than 70 percent sand. Underlying horizons typically have weakly developed physical and chemical properties; they typically have textures of sandy loam, fine sandy loam, loamy sand, or sand; contain less than 18 percent clay and less than 95 percent sand. Organic matter content in the surface horizon typically ranges from 1 to 3 percent, and moist colors vary from brown (10YR 4/3) to very dark grayish brown (10YR 3/2). Depth to secondary carbonates is typically less than 16 inches below the soil surface. 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 (more than 20 inches) 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) Till (4) Residuum
Surface texture	(1) Sandy loam (2) Fine sandy loam
Drainage class	Well drained
Soil depth	20–72 in
Available water capacity (0–40in)	5.9–6.9 in
Calcium carbonate equivalent (0–5in)	5–10%
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 Dry Shrubland 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 Dry Shrubland ecological site evolved under the combined influences of climate, grazing, and fire. Extreme climatic variability results in frequent droughts, which can 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).

Fire is an important dynamic on the Sandy Dry Shrubland ecological site. The historic ecosystem experienced periodic lightning-caused fires. 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). It is difficult to precisely determine the fire-return interval in the Dry Shrubland climate zone, but estimates range from 6 to 25 years (Bragg, 1995) to 10 to 70 years (Howard, 1999). Generally, the herbaceous vegetation is resilient to fire and the primary effects of fire are reduction of litter

and short-term fluctuations in production (Vermeire et al., 2011, 2014). However, studies have shown that very short fire-return intervals (less than 5 years) can have a negative effect, shifting species composition toward warm-season, short-statured grasses (Shay et al., 2001; Smith and McDermid, 2014). Conversely, fire has a significant effect on Wyoming big sagebrush cover. Wyoming big sagebrush is a non-sprouting shrub and is most often killed by fire (Howard, 1999). Often, it may take 30 years or more for a stand to recover following fire (Watts and Wambolt, 1996; Wambolt et al., 2001). It is likely that fire-return intervals shorter than 30 years will result in a reduction in Wyoming big sagebrush cover over the long term. Long-term fire suppression in the 20th century removed periodic fire from the ecosystem altogether. Very little is known how this has affected the Dry Shrubland ecosystem. Some studies suggest an increase in Wyoming big sagebrush cover, presumably due to fire suppression (Bloom-Cornelius, 2011). Increased decadence in Wyoming big sagebrush may also occur (Howard, 1999), but these results are inconclusive.

Lack of periodic fires can also result in an increase in litter accumulation and, in some cases, provide ideal conditions for seed germination and seedling establishment of non-native annual brome species, such as field brome or Japanese brome (*Bromus arvensis*) (Whisenant, 1990). These species have become naturalized in relatively undisturbed grasslands (Ogle et al., 2003; Harms, 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. The fire-recovery cycle is a critical element in managing the Dry Shrubland ecosystem. Further study is needed in this area to determine a balanced and sustainable fire cycle.

Improper grazing of this site can result in a reduction in the cover of the mid-statured bunchgrasses and an increase in blue grama (*Bouteloua gracilis*) (Smoliak et al., 1972; Smoliak, 1974). Eventually, improper grazing may also begin to reduce sedges. Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year, and that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and inadequate seasonal rotation moves over multiple years. Periods of extended drought can reduce mid-statured, cool-season grasses and shift the species composition of this community to one dominated by blue grama (Coupland, 1958, 1961). Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as blue grama. Cover of mid-statured grasses is severely reduced or absent.

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, the site is either allowed to revert back to perennial grassland or is seeded with introduced 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 (Lesica and DeLuca, 1996). Crested wheatgrass can invade relatively undisturbed grasslands, reducing cover and production of native cool-season midgrasses (Heidinga and Wilson, 2002; Henderson and Naeth, 2005). 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). Without vegetative cover, this ecological site is very susceptible to wind erosion, and severe loss of topsoil is possible. However, those sites seeded with non-native species, particularly crested wheatgrass, may persist with this cover type indefinitely (Christian and Wilson, 1999).

The state-and-transition model (STM) (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 three community phases characterized by mid-statured bunchgrasses, sedges, and mid-statured, warm-season grasses. Wyoming big sagebrush, a perennial, evergreen, non-sprouting shrub occurs at low cover. Lesser spikemoss, also known as dense clubmoss (*Selaginella densa*), is typically absent on this site; however, in some cases it is abundant. Its dynamics on this site are not well understood and no consistent patterns can be identified at this time. This state evolved under the combined influences of climate, grazing, and fire with climatic variation having the greatest influence on cover and production. In general, this state was resilient to grazing, although heavy grazing could influence species composition in localized areas.

Phase 1.1: Shrubland Community Phase

The Shrubland Community Phase (1.1) is characterized by mid-statured, cool-season bunchgrasses, sedges, and mid-statured, warm-season grasses. The most dominant species appear to be needle and thread and threadleaf sedge. Prairie sandreed and Indian ricegrass (*Achnatherum hymenoides*) become common as soil textures become coarser. As soil textures become finer, prairie sandreed decreases and is replaced by a variety of other native grasses such as western wheatgrass (*Pascopyrum smithii*), prairie Junegrass (*Koeleria macrantha*), and Sandberg bluegrass (*Poa secunda*). The warm-season little bluestem (*Schizachyrium scoparium*) can also be common, particularly in the eastern extent of this ecological site. The mat-forming, warm-season perennial grass blue grama is the most common shortgrass in this phase. Shortgrasses rarely comprise more than 5 percent of the plant community. Common forbs are dotted blazing star (*Liatris punctata*) and scarlet globemallow (*Sphaeralcea coccinea*). The subshrub soapweed yucca (*Yucca glauca*) is common, but other subshrubs such as prairie sagewort (*Artemisia frigida*) are rare. The principle shrubs on this site are silver sagebrush (*Artemisia cana*) and Wyoming big sagebrush. Canopy cover of Wyoming big sagebrush is approximately 5 percent in this phase. Prairie rose (*Rosa arkansana*) is common in trace amounts. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*

Needle and thread 35%

Threadleaf sedge 20%

Prairie Sandreed 0-20%

Blue grama 5%

Other native grasses 0-20%

Perennial forbs 5%

Soapweed Yucca 10%

Wyoming big sagebrush 5% (canopy cover \approx 5%)

Other shrubs/subshrubs Trace

Estimated Total Annual Production (lbs./ac)*

Low - Insufficient data

Representative Value - 650

High - Insufficient data

*Estimated based on current data – subject to revision

Phase 1.2: Post-Fire Community Phase

The Post-Fire Community Phase (1.2) occurs when the plant community is burned either by wildfire or prescribed fire and may persist for as long as 30 years after burning. It is characterized by mid-statured, cool-season bunchgrasses, sedges, and mid-statured, warm-season grasses. Prairie sandreed and Indian ricegrass become common as soil textures become coarser. As soil textures become finer, prairie sandreed decreases and is replaced by a variety of other native grasses such as western wheatgrass, prairie Junegrass, and, in the eastern extent of this site, little bluestem. Total cover of shortgrasses is similar to Shrubland Community Phase (1.1). Common forbs are dotted blazing star (*Liatris punctata*) and scarlet globemallow (*Sphaeralcea coccinea*). Shrub and subshrub cover is similar to Shrubland Community Phase (1.1) with the exception of Wyoming big sagebrush. Wyoming big sagebrush will be eliminated or nearly so immediately following fire. Recovery of Wyoming big sagebrush depends on many factors including climate, proximity to a seed source, and fire intensity. Typically, there is little or no regeneration for 5 to 10 years post-fire, then cover begins to increase gradually until an equilibrium level is reached (Watts and Wambolt, 1996). Generally recovery is prolonged, sometimes taking as long as 30 years (Wambolt et al., 2001).

Phase 1.3: At Risk Community Phase

The At Risk Community Phase (1.3) occurs when site conditions decline due to drought or improper grazing management. This community phase has nearly equal proportions of shortgrasses and sedges. Shortgrasses, particularly the warm-season, mat-forming blue grama, are increasing in this phase. Mid-statured grasses such as needle and thread have been reduced to low cover and are declining in vigor. Prairie Junegrass, Sandberg bluegrass, and the subshrub, prairie sagewort, also increase in this phase. Cover of Wyoming big sagebrush will vary depending on the length of time since the last burn. If less than 30 years have passed since the last fire big sagebrush cover will be similar to Post-Fire Community Phase (1.2), but 30 years or more post-fire cover will be similar to Shrubland Community Phase (1.1).

Community Phase Pathway 1.1a

Fire will transition the Shrubland Community Phase (1.1) to the Post-Fire Community Phase (1.2). Wyoming big sagebrush is killed and perennial grasses will dominate the site.

Community Phase Pathway 1.1b

Drought, improper grazing management, or a combination of these factors can shift the Shrubland Community Phase (1.1) to the At Risk Community Phase (1.3). These factors favor an increase in blue grama and a decrease in cool-season midgrasses (Coupland, 1961; Shay et al., 2001). Wyoming big sagebrush cover will be similar to the Shrubland Community Phase (1.1).

Community Phase Pathway 1.2a

Thirty years or more of natural vegetative regrowth will transition the Post-Fire Community Phase (1.2) to the Shrubland Community phase (1.1). Thirty years or more without fire permits Wyoming big sagebrush to recolonize the site.

Community Phase Pathway 1.2b

Drought, improper grazing management, or a combination of these factors can shift the Post-Fire Community Phase (1.2) to the At Risk Community Phase (1.3). These factors favor an increase in blue grama and a decrease in cool-season midgrasses (Coupland, 1961; Shay et al., 2001). Wyoming big sagebrush cover will be similar to the Post-Fire Community Phase (1.2).

Community Phase Pathway 1.3a

Less than 30 years post-fire; normal or above-average precipitation and proper grazing management transitions the At Risk Community Phase (1.3) to the Post-Fire Community Phase (1.2).

Community Phase Pathway 1.3b

Thirty years or more post-fire; normal or above-average precipitation and proper grazing management transitions the At Risk Community Phase (1.3) to the Shrubland 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 graminoids become rare and contribute little to production. Shortgrasses such as blue grama dominate the plant community. Threadleaf sedge cover is reduced, and vigor is low.

Transition T1B

The Reference State (1) 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 (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 two community phases. The dynamics of this state are driven by long-term

drought, improper grazing management, or a combination of these factors. Blue grama increases with long-term improper grazing at the expense of cool-season midgrasses (Coupland, 1961; Biondini and Manske, 1996; Derner and Whitman, 2009). Once established, blue grama-dominated communities can alter soil properties, creating conditions that resist establishment of other grass species (Dormaer and Willms, 1990; Dormaar et al., 1994). Reductions in stocking rates can reduce blue grama cover and increase the cover of cool-season midgrasses, although this recovery may take decades (Dormaer and Willms, 1990; Dormaar et al., 1994). Cover of Wyoming big sagebrush varies depending on fire frequency, with dynamics similar to the Reference State (1).

Phase 2.1: Shrub/Shortgrass Community Phase

The Shrub/Shortgrass Community Phase (2.1) occurs when site conditions decline due to long-term drought or improper grazing, and a fire has not occurred on the site for at least 30 years. In this phase, mid-statured grasses have been largely eliminated and replaced by short-statured species, such as blue grama. Cover of threadleaf sedge is low, vigor is poor, and plants are often heavily grazed. Blue grama resists grazing due to its low stature and extensive root system. Erosional patterns and plant pedestaling are evident. Cover of Wyoming big sagebrush is approximately 5 percent.

Phase 2.2: Shortgrass Community Phase

The Shortgrass Community Phase (2.2) occurs when site conditions decline due to long-term drought or improper grazing, and a fire has occurred on the site less than 30 years prior. In this phase, mid-statured grasses have been largely eliminated and replaced by short-statured species, such as blue grama. Cover of threadleaf sedge is low, vigor is poor, and plants are often heavily grazed. Blue grama resists grazing due to its low stature and extensive root system. Erosional patterns and plant pedestaling are evident. Wyoming big sagebrush is rare.

Community Phase Pathway 2.1a

Fire will transition the Shrub/Shortgrass Community Phase (2.1) to the Shortgrass Community Phase (2.2). Wyoming big sagebrush is killed and perennial grasses will dominate the site.

Community Phase Pathway 2.2a

It is believed that 30 years or more of natural vegetative regrowth could transition the Shortgrass Community Phase (2.2) to the Shrub/Shortgrass Community Phase (2.1). It is possible that this transition could occur over time, however, the processes are not fully understood at this time. Therefore, this pathway is considered hypothetical until further investigation can be completed.

Transition T2A

The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses, noxious weeds, and other invasive plants 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 (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

Blue grama can resist displacement by other species (Dormaer and Willms, 1990; Laycock, 1991; Dormaar et al., 1994; Lacey et al., 1995). A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of blue grama in the Shortgrass State (3) (Dormaer and Willms, 1990). 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 (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 seed bank 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).

Other invasive species that could be a concern are annual bromes and noxious weeds. Annual bromes are generally not a significant concern in MLRA 52, however, in the Dry Shrubland, there could be instances where they do significantly affect the site. More information is needed to assess this condition. Noxious weeds such as leafy spurge are uncommon on this site, but they may also invade and displace native species. Although very aggressive, these species can sometimes 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, structural complexity, and soil quality 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. No formal studies have been obtained regarding big sagebrush recovery following cultivation. Preliminary evidence suggests that, initially, silver sagebrush may replace big sagebrush in this state. Further investigation is needed to assess big sagebrush recovery in the Post-Cropland State (5).

Phase 5.1: Abandoned Cropland Phase

The Abandoned Cropland Phase (5.1) 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, blue grama, 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 crested wheatgrass, and annual bromes will depend upon the site's proximity to a seed source.

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

Phase 5.2: Perennial Grass Phase

The Perennial Grass Phase (5.2) occurs when the site is seeded to perennial forage species. When seeded to

introduced species, particularly perennial grasses such as crested wheatgrass, this community phase can persist for several decades. Monocultures of crested wheatgrass can 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 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

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) to the Cropland State (4).

State and transition model

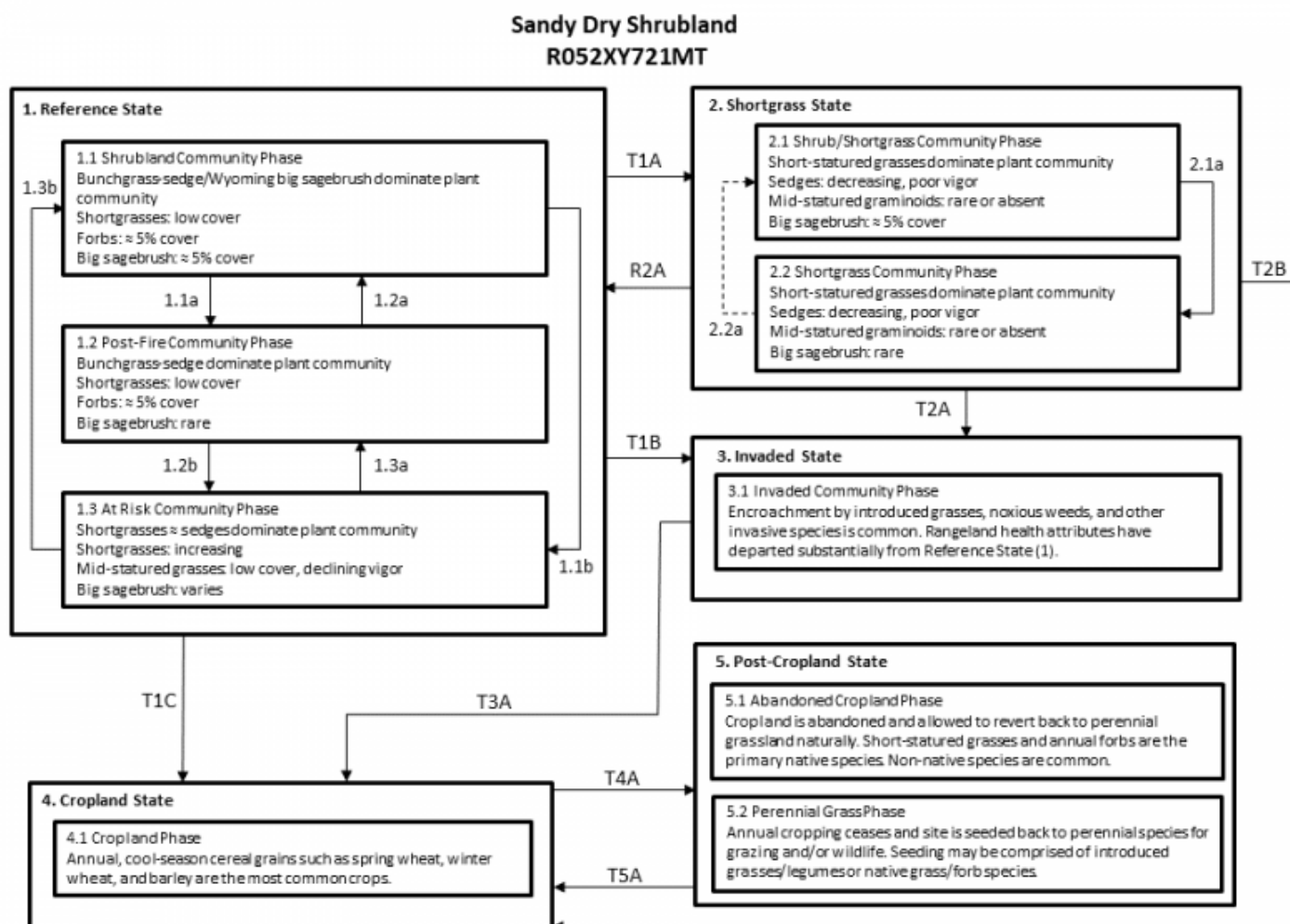


Figure 2. State-and-transition diagram.

**Sandy Dry Shrubland
R052XY721MT**

Legend

- 1.1a, 2.1a - fire
- 1.2a, 2.2a - approximately 30 years post-fire regrowth
- 1.1b - drought, improper grazing management
- 1.2b - drought, improper grazing management
- 1.3a - normal or above average precipitation, proper grazing management (< 30 years post fire)
- 1.3b - normal or above average precipitation, proper grazing management (≥ 30 years post fire)
- 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, timely moisture, proper grazing management (management intensive and costly)
- T1C, T2B, T3A, T5A - conversion to cropland
- T4A - cessation of annual cropping
- Note: dashed arrows represent hypothesized pathways*

Figure 2 (continued). State-and-transition legend.

Inventory data references

One medium-intensity plot was available for this ecological site, this plot was located in the dry grassland/dry shrubland intergrade area and likely represents a transition between the two climate zones. Four low-intensity plots from the Sandy Dry Grassland ecological site were also used for reference. These plots, combined with professional experience and a review of the scientific literature, were used to approximate the reference plant community. Remaining information 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):**
-
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:**
