

## **Ecological site FX052X03X005 Clayey-Steep (Cystp) 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.

### **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 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 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: Xeromorphic Woodland, Scrub and Herb Vegetation Class (3)
- Subclass: Cool Semi-Desert Scrub and Grassland Subclass (3.B)
- Formation: Cool Semi-Desert Scrub and Grassland Formation (3.B.1)
- Division: Cool Semi-Desert Scrub and Grassland Division (3.B.1.Ne)
- Macrogroup: *Artemisia tridentata* - *Artemisia tripartita* ssp. *tripartita* - *Purshia tridentata* Steppe and Shrubland Macrogroup (3.B.1.Ne.3)
- Group: *Artemisia tridentata* - *Artemisia tripartita* - *Purshia tridentata* Big Sagebrush Steppe and Shrubland Group (3.B.1.Ne.3.b)
- Alliance: *Artemisia tridentata* ssp. *wyomingensis* Mesic Steppe and Shrubland Alliance
- Association: *Artemisia tridentata* ssp. *wyomingensis* / *Pascopyrum smithii* Shrub Grassland or *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* 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. Clayey Steep Dry Shrubland is a moderately extensive ecological site occurring on most landscapes in MLRA 52. This ecological site occurs on hillslopes, badlands, and bluffs where clay content of the soil is greater than 35 percent. Slopes vary from 15 to 60 percent.

The distinguishing characteristics of this site are moderately steep to very steep slopes, a relatively well developed soil profile, and clayey textures in the upper 4 inches of soil. Soils are typically moderately deep to very deep (between 20 to 60 inches to bedrock), are derived from shale residuum or clayey till, and typically have an ochric

epipedon. Textures in the upper 4 inches of soil are in the fine textural family and contains greater than 35 percent, but not more than 45 percent, clay. Sometimes the underlying horizons exhibit shrink swell characteristics such as slickensides. This site is typically nonacid, with pH values greater than 5.6 throughout the soil profile. Characteristic vegetation is western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), and Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*).

Preliminary studies indicate that there may also be an acid variant of this site. This variant appears to exhibit retarded shrub growth, reduced cover of cool season bunchgrasses, and increased cover of creeping juniper and prairie sandreed. At this time, this variant cannot be consistently identified as a separate ecological site concept and further investigation is required.

## Associated sites

FX052X03X131	<b>Shallow Clay (Swc) Dry Shrubland</b> This site is adjacent to the Clayey Steep Dry Shrubland ecological site where bedrock occurs near the soil surface. It typically occupies a backslope position similar to the Clayey Steep Dry Shrubland ecological site.
FX052X03X007	<b>Coarse Clay (Coc) Dry Shrubland</b> This site occurs on moderate to steeply sloping hillslopes adjacent to the Clayey Steep Dry Shrubland ecological site. It is commonly in the same landscape positions but has different soil structure.
FX052X03X001	<b>Clayey (Cy) Dry Shrubland</b> This site is adjacent to the Clayey Steep Dry Shrubland ecological site, on slopes of less than 15 percent. It typically occupies a summit position upslope from the Clayey Steep Dry Shrubland ecological site.

## Similar sites

FX052X03X007	<b>Coarse Clay (Coc) Dry Shrubland</b> This site differs from the Clayey Steep Dry Shrubland ecological site in that the soil structure in the surface horizon is coarse granular rather than blocky. Prairie sandreed is a dominant plant species.
FX052X01X005	<b>Clayey-Steep (Cystp) Dry Grassland</b> This site differs from the Clayey Steep Dry Shrubland ecological site in that it has slightly cooler annual temperatures and supports silver sagebrush rather than Wyoming big sagebrush.
FX052X03X131	<b>Shallow Clay (Swc) Dry Shrubland</b> This site differs from the Clayey Steep Dry Shrubland ecological site in that depth to bedrock is less than 20 inches.

**Table 1. Dominant plant species**

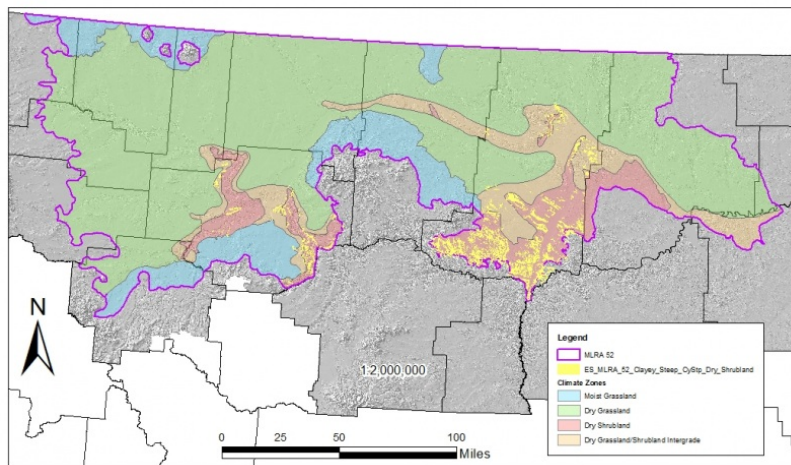
Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

## Legacy ID

R052XY703MT

## Physiographic features

Clayey Steep Dry Shrubland ecological site is moderately extensive, 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 where the till plain has been dissected by streams or rivers. This site is typically in backslope positions on hillslopes, badlands, and bluffs. Slopes vary from 15 to 60 percent.



**Figure 1. Figure 1. General distribution of the Clayey Steep Dry Shrubland ecological site by map unit extent.**

**Table 2. Representative physiographic features**

Hillslope profile	(1) Backslope
Landforms	(1) Till plain > Hillslope (2) Badlands (3) Till plain > Bluff
Elevation	2,000–3,870 ft
Slope	15–60%
Aspect	Aspect is not a significant factor

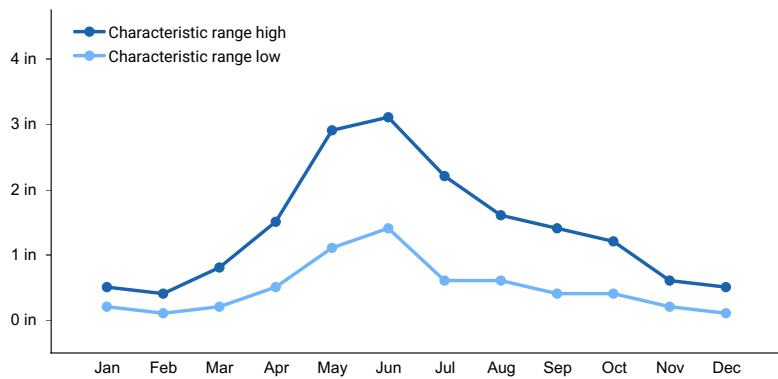
## Climatic features

The Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Cooper et al., 2001). The average frost-free period for this ecological site is 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).

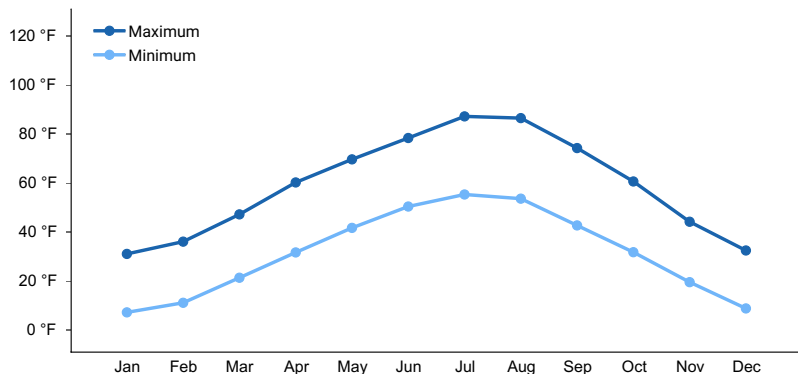
During the winter months, the western half of MLRA 52 commonly experiences chinook winds, which are strong west to southwest surface winds accompanied by abrupt increases in temperature. The chinook winds are strongest on the western boundary of the MLRA near the Rocky Mountain foothills and decrease 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



**Figure 2. Monthly precipitation range**



**Figure 3. Monthly average minimum and maximum temperature**

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

## Soil features

Soil series that best represent the central concept of this ecological site are Bascovy and Megonot, but only when these series occur on slopes 15 percent or greater. Megonot in particular, may also occur on the Clayey Dry Shrubland ecological site. The Bascovy series is in the Haplustert great group and the Megonot series is in the Haplustept great group. Both of these soils are characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon. The Megonot series has weakly developed underlying horizons that exhibit some shrink-swell properties. The Bascovy series has underlying horizons that exhibit strong shrink-swell characteristics evidenced by slickensides (USDA-NRCS, 2016). The particle-size family for both of these soils is fine, which means that the soils contain between 35 and 60 percent clay in the particle-size control section. The soil minerology is smectitic. Typically, the parent material for these soils is clayey residuum or clayey till over residuum. 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 textures found on this site are typically clay, clay loam, or silty clay loam. The upper 4 inches of soil contains greater than 35 percent, but not more than 45 percent clay. The underlying horizons typically contain 35 to 60 percent clay and have clay, clay loam, or silty clay loam textures. Organic matter content in the surface horizon typically ranges from 1 to 2 percent, and moist colors vary from grayish brown (2.5Y 5/2) to dark grayish brown (2.5Y 4/2). Calcium carbonate equivalent is typically less than 10 percent throughout the soil profile. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH class is moderately acid to slightly alkaline in the surface horizon and neutral to strongly alkaline in the subsurface horizons. The soil depth class for this site ranges from moderately deep (more than 20 inches) in places where bedrock is present to very deep. Content of coarse fragments is less than 35 percent in the upper 20 inches of soil and is typically less than 15 percent.

**Table 4. Representative soil features**

Parent material	(1) Residuum (2) Till
Surface texture	(1) Clay (2) Clay loam (3) Silty clay loam
Drainage class	Well drained
Soil depth	20–72 in
Available water capacity (0–40in)	3.5–4.7 in
Calcium carbonate equivalent (0–5in)	0–14%
Electrical conductivity (0–20in)	0–3 mmhos/cm
Sodium adsorption ratio (0–20in)	0–12
Soil reaction (1:1 water) (0–40in)	5.6–9
Subsurface fragment volume ≤3" (0–20in)	0–34%
Subsurface fragment volume >3" (0–20in)	0–34%

## Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM) (Figure 2), was developed based on historical data, current field data, professional experience, and a review of the scientific literature. As a result, all possible scenarios or plant species may not be included. Key indicator plant species, disturbances, and ecological processes are described to inform land management decisions.

The Clayey Steep Dry Shrubland ecological site in MLRA 52 consists of three states: the Reference State (1), the Shortgrass State (2), and the Invaded State (3). Plant communities associated with the Clayey Steep 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 a critical dynamic on the Clayey Steep Dry Shrubland ecological site. The historic ecosystem experienced periodic lightning-caused fires. Historically, Native Americans also set fires periodically. 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). It is believed that the frequency and intensity of fire would be less on the Clayey Steep Dry Shrubland ecological site than on adjacent sites due to the broken topography and sparser vegetation. 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 (Hafkamp 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 cool-season midgrasses and an increase in blue grama (Smoliak et al., 1972; Smoliak, 1974). Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year; and, that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and inadequate seasonal rotation moves over multiple years. Periods of extended drought (approximately 3 years or greater) can reduce mid-statured, cool-season grasses and shift the species composition of this community to one dominated by blue grama (Coupland, 1958, 1961). Long-term improper grazing can shift the species composition of this community to one dominated by shortgrasses, such as blue grama and Sandberg bluegrass.

Due to the steep slopes, this ecological site is generally not suitable for cropland. In general, this site has remained intact, although many acres have been invaded by aggressive, perennial introduced grasses, particularly crested wheatgrass (*Agropyron cristatum*). 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 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). Clayey Steep Dry Shrubland ecological sites adjacent to these seeded areas are particularly prone to invasion.

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 three community phases characterized by rhizomatous grasses, mid-statured cool-season bunchgrasses, and Wyoming big sagebrush, a perennial, evergreen, non-sprouting shrub. 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 dominated by rhizomatous wheatgrasses, mid-statured bunchgrasses, and Wyoming big sagebrush. Typically, the most abundant herbaceous species are western wheatgrass and green needlegrass. Thickspike wheatgrass may also be present, becoming more abundant in the northern extent of this ecological site. Bluebunch wheatgrass (*Pseudoroegneria spicata*) may occur on this site, but is typically limited to the southern portions of Phillips and Valley Counties where soils are moderately deep to the Bear Paw Shale Formation. Short-statured, grasses, such as blue grama (*Bouteloua gracilis*), prairie Junegrass (*Koeleria macrantha*), and Sandberg bluegrass (*Poa secunda*), are common although cover and production are low. Needleleaf sedge (*Carex duriuscula*) and plains muhly (*Muhlenbergia cuspidata*) may also be present at low cover. Common forbs are American vetch (*Vicia americana*), and spiny or Hood's phlox (*Phlox hoodii*). The principle shrub on this site is Wyoming big sagebrush, canopy cover is typically 5 to 15 percent. Subshrubs are rare and include prairie sagewort (*Artemisia frigida*), and broom snakeweed (*Gutierrezia sarothrae*). The approximate species composition of the reference plant community is as follows:

##### Percent composition by weight\*

Rhizomatous wheatgrass 20-35%

Bluebunch wheatgrass 0-15%

Green needlegrass 20%

Plains muhly 5%

Blue grama 5%

Other native grasses 10%

Perennial forbs 5%

Wyoming big sagebrush 15% (canopy cover 5-15%)

Other shrubs/subshrubs 5%

##### Estimated Total Annual Production (lbs./ac)\*

Low - 300

Representative Value - 550

High - 800

\*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 a wheatgrass-bunchgrass plant community. The most abundant mid-statured species are western wheatgrass and green needlegrass. Blue grama, prairie Junegrass, and Sandberg bluegrass are common short-statured grasses. Total cover of shortgrasses is similar to the Shrubland Community Phase (1.1). 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 the site condition declines due to drought or improper grazing management. Multiple fires in close succession can also transition the site to this phase. This community phase is characterized by nearly equal proportions of shortgrasses and rhizomatous wheatgrasses. Green needlegrass is



rare or absent while other mid-statured bunchgrasses such as plains muhly are declining in cover and vigor. Shortgrasses, particularly the warm-season, mat-forming blue grama, are increasing in this phase. 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, Wyoming big sagebrush cover will be similar to the Post-Fire Community Phase (1.2), but 30 years or more post-fire cover will be similar to the 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

30 years or more of natural vegetative regrowth will transition the Post-Fire Community Phase (1.2) to the Shrubland Community Phase (1.1). 30 years or more without fire permits Wyoming big sagebrush to recolonize the site.

#### Community Phase Pathway 1.2b

Drought, improper grazing management, multiple fires in close succession, 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

30 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, Sandberg bluegrass, and prairie Junegrass 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 Shortgrass State (2). Crested wheatgrass, in particular, is a concern 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).

#### State 2: Shortgrass State

The Shortgrass State 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 (Dormaar 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 (Dormaar 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 such as green needlegrass and rhizomatous wheatgrasses 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. Prairie sagewort may also increase in this phase. Cover of Wyoming big sagebrush is 5 to 15 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 such as green needlegrass and rhizomatous wheatgrasses 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. Prairie sagewort may also increase in this phase. Wyoming big sagebrush is rare.

#### 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). Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced.

#### 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). A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of blue grama in the Shortgrass State (3) (Dormaar 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 may not be possible on this site due to topography. Therefore, returning the Shortgrass State (2) to the Reference State (1) can require considerable cost, energy, and may not be feasible within a reasonable amount of time.

#### 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

Thirty years or more of natural vegetative regrowth will transition the Shortgrass Community Phase (2.2) to the Shrub/Shortgrass Community Phase (2.1). It is believed that 30 years or more without fire will permit Wyoming big sagebrush to recolonize the site, however, conclusive documentation has not yet been obtained. Therefore, this pathway is considered hypothetical until further investigation can be completed.

#### 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 Clayey Steep Dry Shrubland ecological site, 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.

## State and transition model

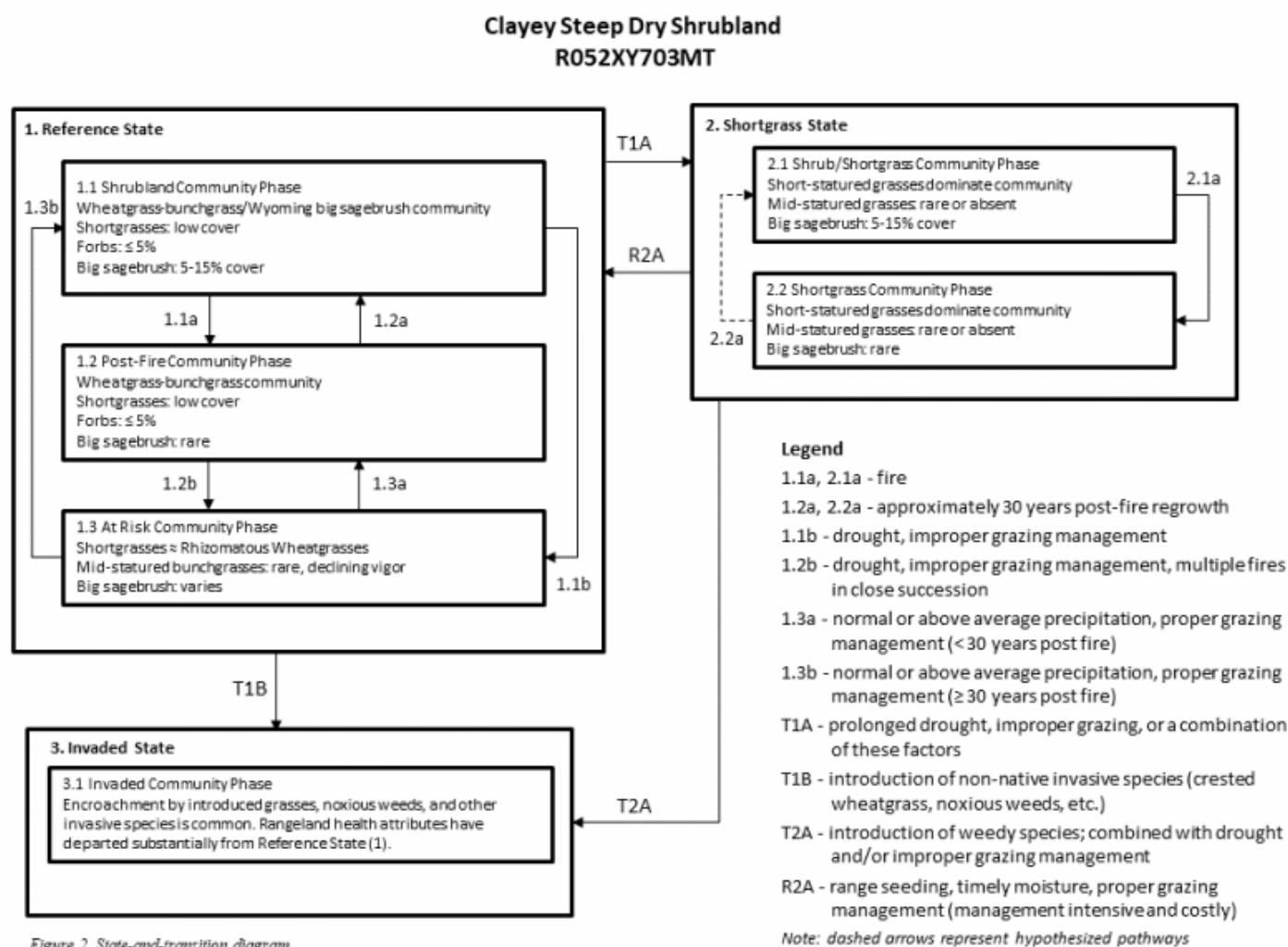


Figure 2. State-and-transition diagram.

## Inventory data references

Very little field data was available for this provisional ecological site. No plots were available specifically for this site. A combination of professional experience and data from similar ecological sites was used to approximate the reference plant community. Remaining information 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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## Approval

Kirt Walstad, 12/28/2022

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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	04/29/2024
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

## Indicators

### 1. Number and extent of rills:

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### 2. Presence of water flow patterns:

---

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

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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:**
-