USDA Natural Resources
Conservation Service

Ecological site FX052X03X160
Thin Breaks (TB) 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.

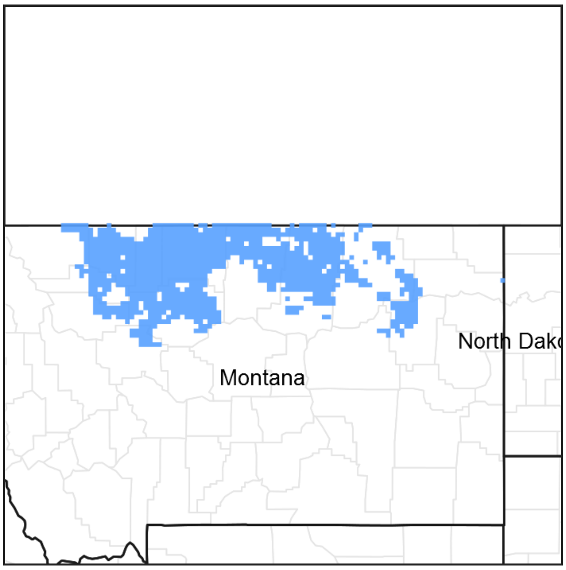

Figure 1. Mapped extent

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 the till is sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007). The bedrock is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur along glacial outwash channels and major drainages, including portions of the Missouri, Teton, Marias, Milk, and Frenchman Rivers. Large glacial lakes, particularly in the western half of the MLRA, deposited clayey and silty lacustrine sediments (Fullerton et al., 2013).

Much of the western portion of this MLRA was glaciated towards the end of the Wisconsin age, 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 Illinoisan age. Due to erosion and dissection of the landscape, many of these areas have steeper slopes and more exposed bedrock than areas glaciated during the Wisconsin age (Fullerton and Colton, 1986).

While much of the rangeland in the aridic-ustic portion of MLRA 52 is classified as belonging to the “dry grassland” climatic zone, sites in portions of southern MLRA 52 may belong to the “dry shrubland” climatic zone. The Dry Shrubland climatic zone represents the northernmost extent of the big sagebrush (Artemisia tridentata) steppe on the Great Plains. Because similar soils occur in both southern and northern portions of the MLRA, it is currently hypothesized that climate is the primary driving factor affecting big sagebrush distribution in this area. However, the precise factors are not 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 because many individuals overwinter in the big sagebrush steppe (dry shrubland) in the southern portion of the MLRA and then migrate to the northern portion of the MLRA, which lacks big sagebrush (dry grassland), to live the rest of the year (Smith, 2013).

Areas of the till plain near the Bearpaw and Highwood Mountains as well as the Sweetgrass Hills and Rocky Mountain foothills are at higher elevations, receive higher amounts of precipitation, and have a typic-ustic moisture regime. These areas have significantly more rangeland production than the drier aridic-ustic portions of the MLRA and have enough moisture to produce crops annually rather than just bi-annually, as in the drier areas. Ecological sites in this higher precipitation area are classified as the Moist Grassland climatic zone.

Classification relationships

NRCS Soil Geography Hierarchy
• Land Resource Region: Northern Great Plains
• Major Land Resource Area (MLRA): 052 Brown Glaciated Plains
• Climate Zone: 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 ssp. wyomingensis - Artemisia tridentata ssp. tridentata Steppe and Shrubland Group (3.B.1.Ne.3.a)

• Alliance: Artemisia tridentata ssp. wyomingensis Dry Steppe and Shrubland 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 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. Thin Breaks Dry Shrubland is a somewhat extensive ecological site occurring on steep or dissected landscapes in MLRA 52. This ecological site occurs on hillslopes, bluffs, and escarpments. This site is typically found on side slopes, nose slopes, and head slopes in a badlands landscape. Due to the complex nature of the landscape, soil texture, soil depth, and slope on this ecological site can be highly variable.

The distinguishing characteristics of this site are lithic or paralithic bedrock within 40 inches of the soil surface and a relatively young, undeveloped soil profile, which lacks features such as a mollic epipedon and an argillic horizon. Soils range from very shallow (less than 12 inches to bedrock) to moderately deep (between 20 to 40 inches to bedrock) and are typically derived from residuum. Soil surface textures vary from sandy loam to clay loam and clay content is less than 35 percent. Slopes vary, but are typically greater than 15 percent. Characteristic vegetation is needle and thread (Hesperostipa comata), western wheatgrass (Pascopyrum smithii), and threadleaf sedge (Carex filifolia). Little bluestem (Schizachyrium scoparium) becomes common in the eastern portion of this ecological site. The principle shrub on this site is Wyoming big sagebrush (Artemisia tridentata wyomingensis).

Associated sites

FX052X03X131	**Shallow Clay (Swc) Dry Shrubland** This site is adjacent to the Thin Breaks Dry Shrubland ecological site where soils contain greater than 35 percent clay. It typically occupies a backslope position similar to the Thin Breaks Dry Shrubland ecological site.
FX052X03X007	**Coarse Clay (Coc) Dry Shrubland** This site occurs on moderate to steeply sloping hillslopes adjacent to the Thin Breaks Dry Shrubland ecological site where soils contain greater than 35 percent clay and have a strong granular structure. It is commonly in the same landscape positions as Thin Breaks Dry Shrubland ecological site.
FX052X03X029	**Limy-Steep (Lystp) Dry Shrubland** This site is generally upslope from the Thin Breaks Dry Shrubland ecological site. It is most commonly on shoulder positions above Thin Breaks Dry Shrubland ecological site.

Similar sites

FX052X01X160	**Thin Breaks (TB) Dry Grassland** This site differs from the Thin Breaks Dry Shrubland ecological site in that it has slightly cooler annual temperatures and supports silver sagebrush rather than big sagebrush.
FX052X03X131	**Shallow Clay (Swc) Dry Shrubland** This site differs from the Thin Breaks Dry Shrubland ecological site in that the clay content is greater than 35 percent and depth to bedrock is less than 20 inches.
FX052X03X029	**Limy-Steep (Lystp) Dry Shrubland** This site differs from the Thin Breaks Dry Shrubland ecological site in that the soil depth is greater than 40 inches and soils are typically derived from glacial till rather than residuum. Herbaceus production, particularly of mid-statured bunchgrasses, is significantly higher.
FX052X03X040	**Loamy-Steep (Lostp) Dry Shrubland** This site differs from the Thin Breaks Dry Shrubland ecological site in that the soil is typically greater than 40 inches deep and derived from glacial till. When moderately deep (20 to 40 inches) soils are well developed (evidenced by a mollic epipedon and/or argillic horizon).

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY726MT

Physiographic features

Thin Breaks Dry Shrubland ecological site is a somewhat extensive ecological site occurring across the till plains and moraines of MLRA 52. The majority of MLRA 52 is covered by a broad till plain. This ecological site largely occurs where the till plain has been dissected by streams or rivers and bedrock is exposed. This site is typically on side slopes, nose slopes, and head slopes on hillslopes, bluffs, and escarpments. Slopes vary from 0 to 60 percent, but are typically greater than 15 percent.

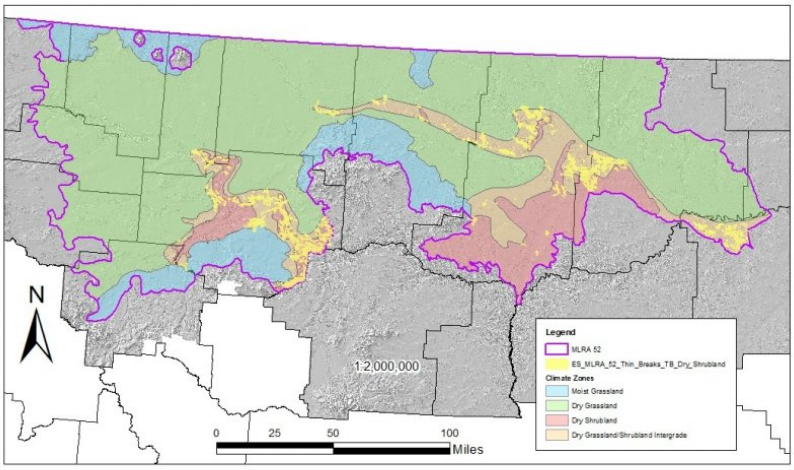

Figure 2. Figure 1. General distribution of the Thin Breaks Dry Shrubland ecological site by map unit extent.

Table 2. Representative physiographic features

Geomorphic position, hills	(1) Side Slope (2) Nose Slope (3) Head Slope
Landforms	(1) Till plain > Hillslope (2) Till plain > Bluff (3) Till plain > Escarpment
Elevation	610–1,180 m
Slope	0–60%
Aspect	Aspect is not a significant factor

Climatic features

The Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Cooper et al., 2001). The average frost-free period for this ecological site is 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)	330 mm

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. Steep slopes combined with bedrock at relatively shallow depths result in very high runoff potential. Intense precipitation events deliver large amounts of surface runoff downslope. 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. 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 of this ecological site are the Cabbart, Blacksheep, Delpoint, and Twilight soils. Cabbart and Blacksheep soils are in the Ustorthents great group. They are in the loamy family and are shallow (between 10 to 20 inches to bedrock). Delpoint and Twilight soils are in the Haplustepts great group and are moderately deep (20 to 40 inches) to bedrock. Delpoint soil is in the fine-loamy family and the Twilight soil is in the coarse-loamy family. All four of these soils have mixed mineralogy. All soils in this concept are characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon and contact with lithic or paralithic bedrock less than 40 inches below the soil surface. 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 are typically fine sandy loam, loam, silt loam, or sandy clay loam. The upper 4 inches of soil contains less than 35 percent clay and sand content is typically less than 70 percent. The underlying horizons are typically weakly developed and an argillic horizon is lacking. Subsurface textures are typically similar to the surface horizon. Organic matter content in the surface horizon typically ranges from 1 to 2 percent, and moist colors vary from yellowish brown (10YR 5/4) to very dark grayish brown (10YR 3/2). Calcium carbonate equivalent varies from 0 to 10 percent, but is typically more than 5 percent. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH class is slightly acid to strongly alkaline in the surface horizon and neutral to strongly alkaline in the subsurface horizons. The soil depth class for this site can vary from very shallow (less than 10 inches to bedrock) to moderately deep (20 to 40 inches to bedrock) and typically changes quickly on the landscape. Content of coarse fragments is less than 35 percent in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Residuum (2) Till
Surface texture	(1) Fine sandy loam (2) Loam (3) Silt loam (4) Sandy clay loam
Drainage class	Well drained
Soil depth	0–102 cm
Available water capacity (0-101.6cm)	5.33–13.21 cm
Calcium carbonate equivalent (0-12.7cm)	0–9%
Electrical conductivity (0-50.8cm)	0–3 mmhos/cm
Sodium adsorption ratio (0-50.8cm)	0–12
Soil reaction (1:1 water) (0-101.6cm)	6.1–9
Subsurface fragment volume <=3" (0-50.8cm)	0–34%
Subsurface fragment volume >3" (0-50.8cm)	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 Thin Breaks 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 Thin Breaks 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 Thin Breaks 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). It is believed that the frequency and intensity of fire would be less on the Thin Breaks 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; 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. 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 some acres have been invaded by aggressive, perennial introduced grasses, particularly crested wheatgrass. Seeding of introduced grasses, particularly crested wheatgrass (*Agropyron cristatum*), was a common practice in 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, 1996). It can invade relatively undisturbed grasslands, reducing cover and production of native cool-season midgrasses (Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Thin Breaks ecological sites adjacent to these seeded areas are particularly prone to invasion.

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 (Figure 2). Landowners and land managers should seek guidance from local professionals before prescribing a particular management or treatment scenario. Plant community responses vary across this MLRA due to variability in weather, soils, and aspect. The reference community phase may not necessarily be the management goal. The lists of plant species and species composition values are provisional and are not intended to cover the full range of conditions, species, and responses for the site. Species composition by dry weight is provided when available and is considered provisional based on the sources identified in the narratives associated with each community phase.

State 1: Reference State
The Reference State (1) contains two community phases characterized by mid-statured, cool-season rhizomatous grasses, mid-statured, cool-season bunchgrasses, and threadleaf sedge, a deep-rooted densely tufted sedge. This state evolved under the combined influences of climate, grazing, and fire with climatic variation having the greatest influence on cover and production (Coupland, 1958, 1961; Biondini et al., 1998). In general, this state was resilient to grazing and fire, although these factors 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 rhizomatous grasses, mid-statured, cool-season bunchgrasses, and Wyoming big sagebrush. The most abundant species are western wheatgrass and needle and thread. Thickspike wheatgrass (*Elymus lanceolatus*) may also be present, becoming abundant in the northern extent of this ecological site. The warm-season bunchgrass little bluestem appears on this site in the eastern extent of its distribution. When present, it occurs in monoculture patches that encompass approximately 10 percent of the site. Short-statured grasses such as blue grama (*Bouteloua gracilis*) are not abundant in this phase but are generally present at low cover. Other species that may occur on this site are plains muhly (*Muhlenbergia cuspidata*), prairie Junegrass (*Koeleria macrantha*), and prairie sandreed (*Calamovilfa longifolia*). Common forbs are scarlet globemallow (*Sphaeralcea coccinea*), dotted blazing star (*Liatris punctata*), and spiny phlox or Hood's phlox (*Phlox hoodii*). The principle shrub on this site is Wyoming big sagebrush, canopy cover is typically 5 to 10 percent. Other shrubs and subshrubs that may occur on this site are prairie sagewort or fringed sagewort (*Artemisia frigida*), creeping juniper (*Juniperus horizontalis*), and winterfat (*Krascheninnikovia lanata*) can occur at low cover. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Rhizomatous Wheatgrass 20-25%
Needle and Thread 20-25%
Threadleaf Sedge 10%
Little Bluestem 0-10%
Blue Grama 5%
Other Native Grasses 10%
Perennial Forbs 10%
Wyoming big sagebrush 10% (canopy cover 5-10%)
Other shrubs/subshrubs 5%

Estimated Total Annual Production (lbs./ac)*
Low - 50
Representative Value - 350
High - 500
*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 rhizomatous grasses, mid-statured, cool-season bunchgrasses, and threadleaf sedge. The warm-season bunchgrass such as little bluestem appears on this site in the eastern extent of its distribution. When present, it occurs in monoculture patches that encompass approximately 10 percent of the site. Total cover of shortgrasses is similar to Shrubland Community Phase (1.1). Other species that may occur on this site are plains muhly, prairie Junegrass, and prairie sandreed. Common forbs are scarlet globemallow, dotted blazing star, and spiny phlox or Hood's phlox. 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 a shortgrass-threadleaf sedge community. Mid-statured grasses, such as needle and thread and rhizomatous wheatgrasses are in decline. Shortgrasses such as blue grama and prairie Junegrass are in equal or greater proportion to mid-statured grasses and are increasing. Threadleaf sedge is common. Prairie sagewort may also increase in this phase. Bare ground increases in extent, making the site more susceptible to erosion by wind and water. 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 shortgrasses and a decrease in cool-season midgrasses (Coupland, 1961). 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 shortgrasses and a decrease in cool-season midgrasses (Coupland, 1961). 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 grasses become rare and contribute little to production. Shortgrasses, particularly the warm-season, mat-forming blue grama, prairie Junegrass, and Sandberg bluegrass dominate the plant community.

Transition T1B
The Reference State (1) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Reference State (1). Crested wheatgrass, in particular, can be 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 and 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 (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 (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 have been eliminated or nearly so 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. Vigor and production of

threadleaf sedge is also declining in this phase. In the eastern extent of this ecological site, a blue grama-little bluestem plant community may develop if pastures are grazed when little bluestem is mature and unpalatable. Dynamics of this plant community are not well understood and require further investigation. Cover of Wyoming big sagebrush is 5 to 10 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 eliminated or nearly so 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. Vigor and production of threadleaf sedge is also declining in this phase. In the eastern extent of this ecological site, a blue grama-little bluestem plant community may develop if pastures are grazed when little bluestem is mature and unpalatable. Dynamics of this plant community are not well understood and require further investigation. Wyoming big sagebrush is rare.

Transition T2A
The Shortgrass State (2) transitions to the Invaded State (3) when non-native 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 (2) (Dormaar and Willms, 1990). Intensive management treatments may be necessary (Hart et al., 1985), but practices such as grazing land mechanical treatment 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 energy, and cost, 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 primarily when aggressive, introduced perennial grasses invade adjacent native grassland communities. Crested wheatgrass in particular, can be a 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 (Christian and Wilson, 1999; Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Once established, monocultures of crested wheatgrass can persist for at least 60 years (Krzic et al., 2000; 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 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

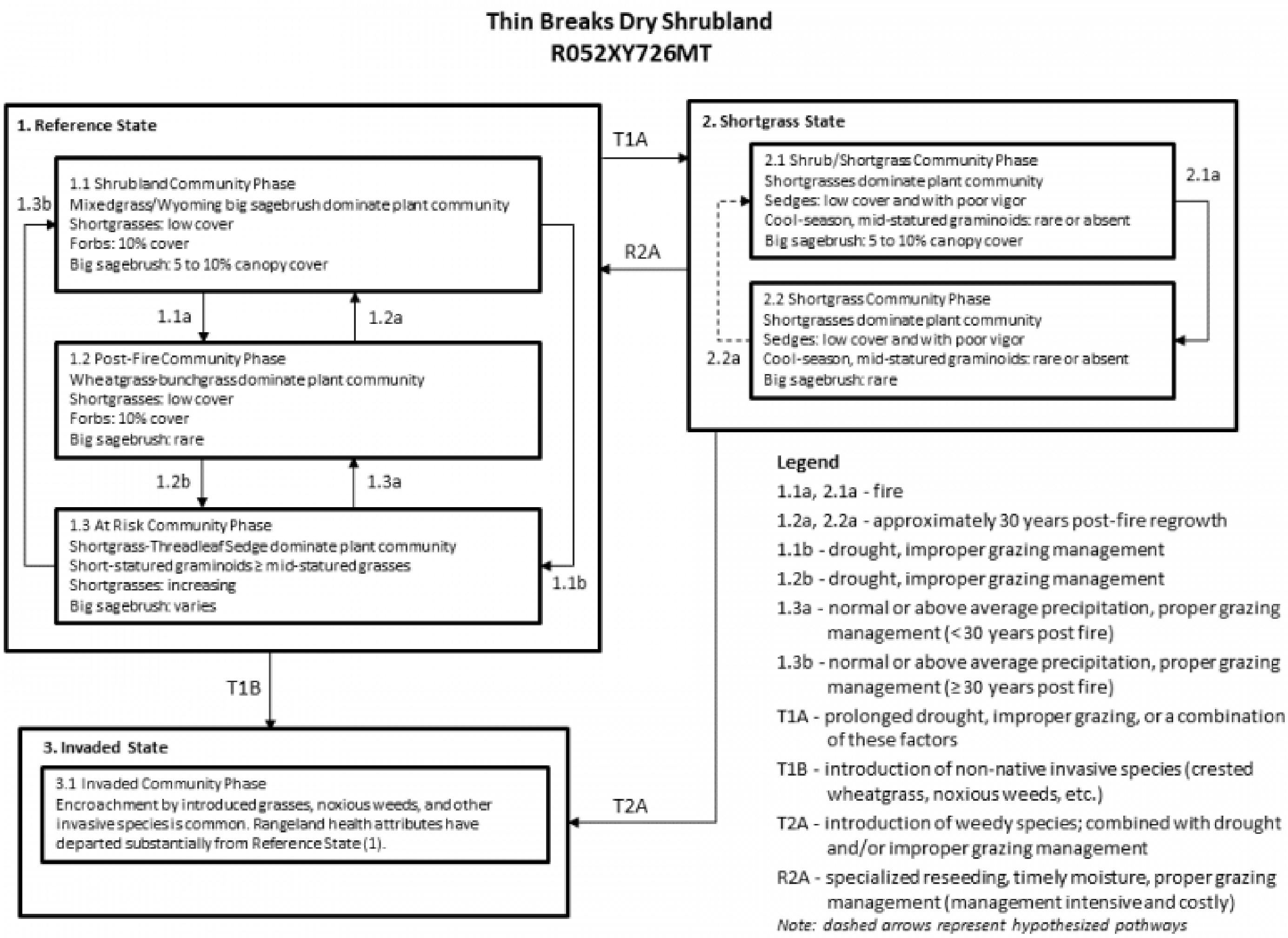

Figure 2. State-and-transition diagram and legend.

Inventory data references

Data for this provisional ecological site was obtained from seven low-intensity plots and one medium-intensity plot. 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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Approval

Scott Brady, 7/08/2019

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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:**