Ecological site FX052X03X007
Coarse Clay (Coc) 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.

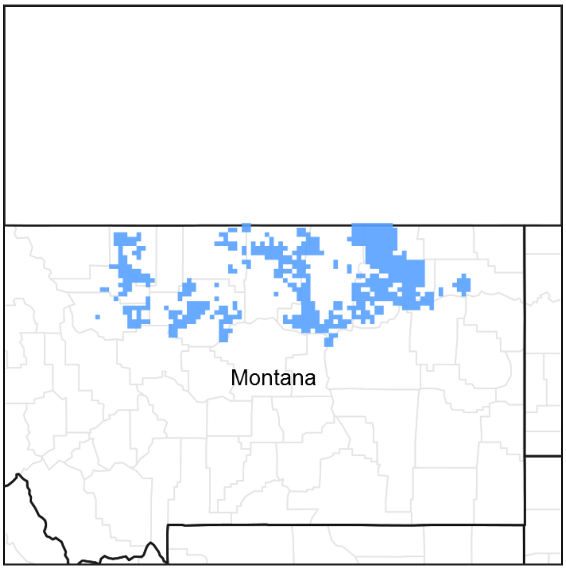

Figure 1. Mapped extent

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, however, 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 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 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: Cryptogam – Open Mesomorphic Vegetation Class (6)
• Subclass: Temperate and Boreal Open Rock Vegetation Subclass (6.B)
• Formation: Temperate and Boreal Cliff, Scree and Other Rock Vegetation Formation (6.B.1)
• Division: Polypodium virginianum – Asplenium platyneuron – Eriogonum spp. Cliff and Rock Vegetation Division (6.B.1.Na)
• Macrogroup: Great Plains Badlands Vegetation Macrogroup (6.B.1.Na.3)
• Group: Sarcobatus vermiculatus / *Eriogonum pauciflorum – Gutierrezia sarothrae* Badlands Group (6.B.1.Na.3.a)
• Alliance: *Artemisia longifolia* Badlands Alliance

• Association: *Artemisia longifolia* – Calamovilfa longifolia Sparse Vegetation

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. Onsite evaluations are necessary, particularly in boundary or intergrade areas where ecological sites from multiple climate zones may overlap. Coarse Clay Dry Shrubland is an ecological site of limited-extent occurring on dissected till plain landscapes in MLRA 52. This ecological site occurs on till plains, hillslopes, and bluffs where erosion has removed glacial till and exposed the underlying bedrock. Soils are clayey, but the surface horizon has a strong granular structure that mimics sand. Soil depth is typically less than 20 inches to bedrock. Slopes vary from 0 to 60 percent, but are typically greater than 15 percent.

The distinguishing characteristics of this site are a clay content greater than 35 percent and strong granular structure in the surface horizon. Soils are derived from clayey residuum or from clayey alluvium over shale. Soil surface textures (upper 4 inches) contain more than 35 percent clay. Underlying horizons are typically weakly developed and commonly contain shale fragments. Calcium carbonate equivalent and pH vary widely. This site is typically acid with little or no calcium carbonate, but in some cases it may be alkaline with up to 15 percent calcium carbonate. Vegetation is typically sparse and soil exposure relatively high. Characteristic vegetation is prairie sandreed (Calamovilfa longifolia), creeping juniper (Juniperus horizontalis), and Wyoming big sagebrush (Artemisia tridentata subsp. wyomingensis).

Associated sites

FX052X03X131	**Shallow Clay (Swc) Dry Shrubland** This site occurs on moderate to steeply sloping hillslopes adjacent to the Coarse Clay Dry Shrubland ecological site. It is frequently in the same landscape position, but has different soil structure and is nonacid.
FX052X03X005	**Clayey-Steep (Cystp) Dry Shrubland** This site occurs on moderate to steeply sloping hillslopes adjacent to the Coarse Clay Dry Shrubland ecological site. It is generally in backslope positions where bedrock is at a depth of 20 inches or more.

Similar sites

FX052X01X007	**Coarse Clay (Coc) Dry Grassland** This site differs from the Coarse Clay Dry Shrubland ecological site in that it has slightly cooler annual temperatures and supports silver sagebrush rather than Wyoming big sagebrush.
FX052X03X005	**Clayey-Steep (Cystp) Dry Shrubland** This site differs from the Coarse Clay Dry Shrubland ecological site in that depth to bedrock is 20 inches or more and it lacks strong granular soil structure in the surface horizon. Prairie sandreed does not dominate the plant community.
FX052X03X131	**Shallow Clay (Swc) Dry Shrubland** This site differs from the Coarse Clay Dry Shrubland ecological site in that it lacks strong granular soil structure in the surface horizon. Prairie sandreed does not dominate the plant community.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY706MT

Physiographic features

Coarse Clay Dry Shrubland ecological site is an ecological site of limited-extent occurring on till plains and bluffs in 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 and underlying bedrock has been exposed. This site is typically in backslope positions on till plains, hillslopes, and bluffs. Slopes are typically 15 to 60 percent.

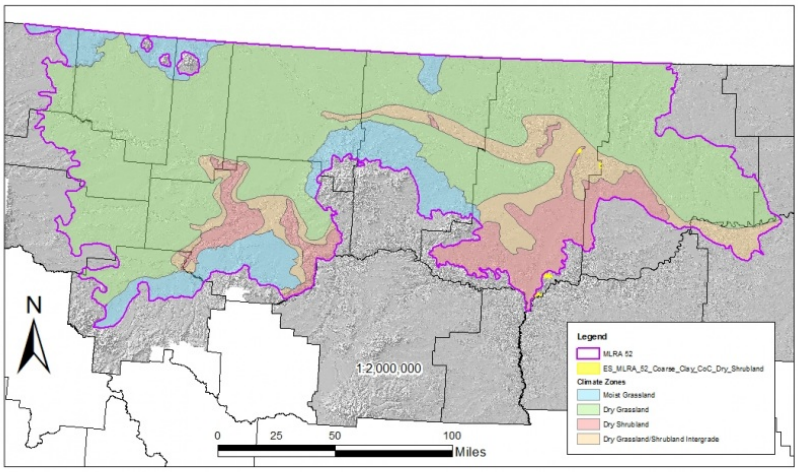

Figure 2. Figure 1. General distribution of the Coarse Clay Dry Shrubland ecological site by map unit extent.

Table 2. Representative physiographic features

Hillslope profile	(1) Backslope
Landforms	(1) Till plain > Hillslope (2) Till plain > Bluff
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 site and the water budget is normally contained within the soil pedon. A combination of steep slopes and the soil's high clay content result in very high runoff potential. Intense precipitation events deliver large amounts of surface runoff downslope. What little moisture is able to infiltrate the soil is quickly lost through evapotranspiration. 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 that best represents the central concept of this ecological site is Volborg. This soil is in the Ustorthents great group. It is characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon, contact with paralithic bedrock within 20 inches of the soil surface, and strong granular structure in the surface horizon. The family is clayey, and minerology is smectitic. The soil moisture regime for 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. All soils have a frigid soil temperature regime (Soil Survey Staff, 2014).

Surface textures found in this site are typically silty clay loam, silty clay or clay and contain more than 35 percent clay. Soil structure in the surface horizon is moderate fine granular to strong medium granular. Underlying horizons are weakly developed and frequently contain shale chips. Organic matter in the surface horizon typically ranges from 1 to 2 percent, and moist colors vary from olive brown (2.5Y 4/3) to dark gray (2.5Y 4/1). Darker colors are typically inherited from the parent material and are not a result of an accumulation of organic matter. As the majority of this site is formed in the non-calcareous Bearpaw formation, the upper 5 inches of these soils typically do not react with hydrochloric acid. However, when this site exists in other formations or where calcareous till or slope alluvium is present the surface may react strongly or violently. The calcium carbonate equivalent in the upper 5 inches is typically negligible but can range up to 14 percent. Soil pH class ranges from very strongly acid to strongly alkaline in the surface and subsurface horizons. The soil depth class for this site is shallow or very shallow (less than 20 inches to bedrock). Content of coarse fragments is typically between 15 and 60 percent by volume in the subsurface horizons. These fragments are typically soft parafragments that are weakly cemented and can be crushed between the fingers.

Table 4. Representative soil features

Parent material	(1) Residuum–shale
Surface texture	(1) Silty clay loam (2) Silty clay (3) Clay
Drainage class	Well drained
Soil depth	0–51 cm
Available water capacity (0-101.6cm)	3.81–5.08 cm

Calcium carbonate equivalent (0-12.7cm)	0–14%
Electrical conductivity (0-50.8cm)	0–3 mmhos/cm
Sodium adsorption ratio (0-50.8cm)	0–12
Soil reaction (1:1 water) (0-101.6cm)	4.5–9
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 Coarse Clay Dry Shrubland ecological site in MLRA 52 consists of three states: the Reference State (1), the Altered State (2), and the Invaded State (3). Plant communities associated with the Coarse Clay 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). Annual production of cool-season graminoids 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 typically a critical dynamic in the Dry Shrubland climate zone, however, fire frequency and intensity are most likely significantly less on the Coarse Clay 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) and 10 to 70 years (Howard, 1999). It is believed that fire had a very limited impact on the Coarse Clay Dry Shrubland ecological site 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). Conversely, fire has a significant effect on Wyoming big sagebrush. 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 about 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 and vigor of the warm-season grasses, reduced vigor in cool-season grasses, and an increase in unpalatable forbs and shrubs. 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. Further degradation of the site due to improper grazing can result in a community dominated by low shrubs and unpalatable forbs such as curlycup gumweed (*Grindelia squarrosa*). Periods of extended drought (approximately 3 years or more) may have similar effects. It is hypothesized that prolonged improper grazing combined with the introduction of invasive species may result in an Invaded State (3). Possible invasive species include field brome, or Japanese brome (Bromus japonicus), saltlover (*Halogeton glomeratus*), and noxious weeds. The Invaded State (3) has not been conclusively documented, and the ecological mechanisms are unclear. The Invaded State (3) is considered hypothetical until further investigation of invasive species dynamics can be completed.

Because of the shallow soil and generally steep slopes, this ecological site is unsuitable for cropland. Therefore, this ecological site has remained in native vegetation.

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 mid-statured warm-season grasses, low shrubs, 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 site is believed to have been protected from fire by topography and low fuel loads. Occasionally, it is possible that fire intensity could be high enough to kill Wyoming big sagebrush, but fire dynamics on this site are not well understood.

Phase 1.1: Shrubland Community Phase
The Shrubland Community Phase (1.1) is characterized by an abundance of mid-statured warm-season grasses. By far, the most common grass is the rhizomatous species prairie sandreed, which may constitute up to 50 percent of the total annual production. Little bluestem (*Schizachyrium scoparium*) may also be present and commonly occurs in large patches. Common cool-season grasses include western wheatgrass (*Pascopyrum smithii*) and prairie Junegrass (*Koeleria macrantha*). Prairie clover (Dalea spp.) is common if the site is nonacid, but is generally absent if the pH is less than 6.1. Other common forbs are American vetch (Vicia Americana) and fewflower buckwheat (*Eriogonum pauciflorum*). Low shrubs are common, but comprise 10 percent or less of the total canopy cover. Common species are creeping juniper and longleaf wormwood (*Artemisia longifolia*). Wyoming big sagebrush also occurs at 1 to 5 percent canopy cover and frequently exhibits a stunted growth form, particularly on acid sites. 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*
Prairie Sandreed 30-50%
Little Bluestem 0-20%
Cool-Season Grasses 15%
Other Native Grasses 10%

Native Perennial Forbs 15%
Wyoming big sagebrush 1-5% (canopy cover 1-5%)
Other shrubs/subshrubs 5-10%

Estimated Total Annual Production (lbs./ac)*
Low - 200
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. Fire frequency and intensity are generally low on the Coarse Clay Dry Shrubland ecological site, therefore occurrence of this phase is probably rare. The most common grass is prairie sandreed. Little bluestem (*Schizachyrium scoparium*) may also be present and commonly occurs in large patches. Other common grass species include western wheatgrass and prairie Junegrass. Grass cover and species composition is similar to the Shrubland Community Phase (1.1). Common forbs include American vetch and fewflower buckwheat. Shrub cover, primarily Wyoming big sagebrush and creeping juniper, is reduced in this phase. Wyoming big sagebrush is usually eliminated or nearly so immediately following fire. Recovery 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). Creeping juniper can be killed by intense fire, but due to the low fire intensity on this ecological site a portion of the creeping juniper cover can survive and regenerate (Gucker, 2006). Further investigation of fire effects is needed to better assess this community phase.

Phase 1.3: At Risk Community Phase
The At-Risk Community Phase (1.3) is characterized by a significant reduction of mid-statured warm-season grasses. Cool-season grasses consist predominantly of short-statured species, such as prairie Junegrass, and exhibit poor vigor and low cover. Unpalatable forbs, such as curlycup gumweed, are increasing in this phase. Low shrubs, particularly common juniper, are common and increasing. 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). 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). 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 Altered State (2). The Reference State (1) transitions to the Altered State (2) when perennial grasses become rare and contribute little to production. Low shrubs and unpalatable forbs dominate the plant community.

Transition T1B
The Reference State (1) transitions to the Invaded State (3) when aggressive invasive species or noxious weeds invade the Altered State (2). The ecological mechanisms of this transition are unclear, therefore this transition is considered hypothetical until further study can be completed.

State 2: Altered State
The Altered State (2) consists of one community phase. The dynamics of this state are driven by long-term drought, improper grazing management, or a combination of these factors. The Altered State is dominated by low shrubs and unpalatable forbs such as curlycup gumweed. Perennial grasses have been eliminated or nearly so, and their vigor and production are low. Once in the Altered State, the site may become unstable and is subject to erosion and solar heating. Cover of Wyoming big sagebrush varies depending on the length of time since the last fire. Fire is not believed to be a significant dynamic occurring within this state because vegetative cover is insufficient to carry it.

Phase 2.1: Shrub/Forb Community Phase
In the Shrub/Forb Community Phase (2.1), low shrubs, particularly creeping juniper, dominate this community phase. Longleaf wormwood, more commonly known as longleaf sagebrush, may be common in acidic areas while broom snakeweed is significant in nonacid areas. Unpalatable forbs such as curlycup gumweed and prairie thermopsis (*Thermopsis rhombifolia*) are common. Perennial grasses have been eliminated or nearly so. There is a high amount of bare ground, and soils are unstable and subject to erosion. 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).

Transition T2A
The Altered State (2) transitions to the Invaded State (3) when aggressive invasive species or noxious weeds invade the Altered State (2). The ecological mechanisms of this transition are unclear, therefore this transition is considered hypothetical until further study can be completed.

Restoration Pathway R2A
A change in management alone may not be sufficient to restore the Altered State (1) to the Reference State (1). Intensive restoration methods may be necessary to reestablish desirable species. Reseeding via conventional methods may not be possible due to the steep topography of this site. Specialized reseeding techniques (hydroseeding, use of straw wattles, etc.) may be necessary. These restoration methods are labor intensive and costly and may not be practical in all situations.

State 3: Invaded State
The Invaded State (3) occurs primarily when invasive, non-native species invade native grassland communities. Anecdotal observations of this state have been made, but conclusive documentation has not yet been obtained. This state is considered hypothetical until further investigation of invasive species dynamics can be completed. Possible invasive species include Japanese brome, saltlover, halogeton, and noxious weeds.

State and transition model

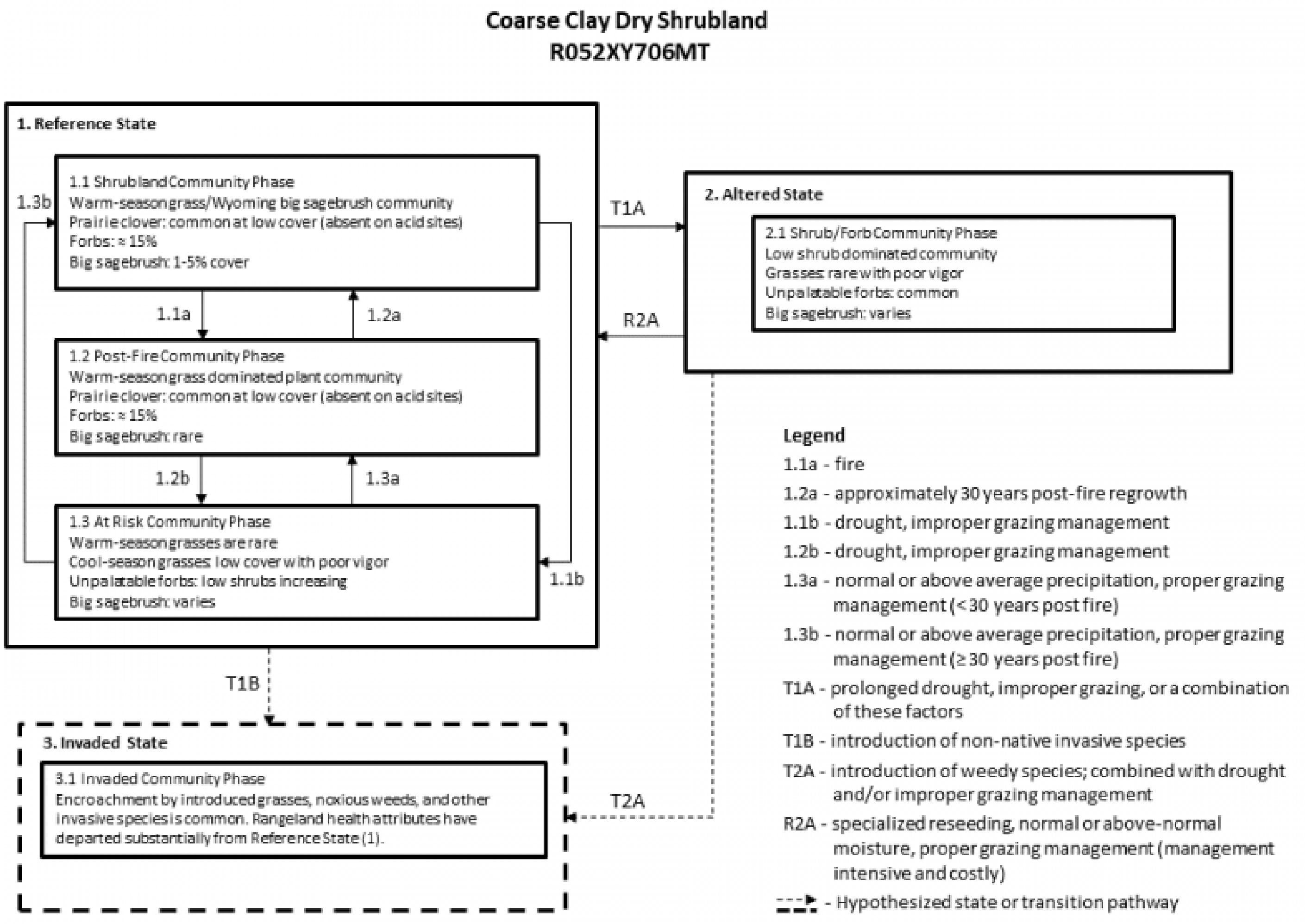

Figure 2. State-and-transition model (STM) diagram.

Inventory data references

One low intensity plot was available for this site. This was supplemented with two historical (417) plots for the Coarse Clay Dry Grassland ecological site. These plots, in combination with professional experience and a review of the scientific literature, were 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.

Other references

Adams, B.W., et al. 2013. Rangeland plant communities for the dry mixedgrass natural subregion of Alberta. Second approximation. Rangeland Management Branch, Policy Division, Alberta Environment and Sustainable Resource Development, Lethbridge, Pub. No. T/040.

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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:**