USDA Natural Resources Conservation Service

Ecological site FX052X01X145 Panspot (Pn) Dry Grassland

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

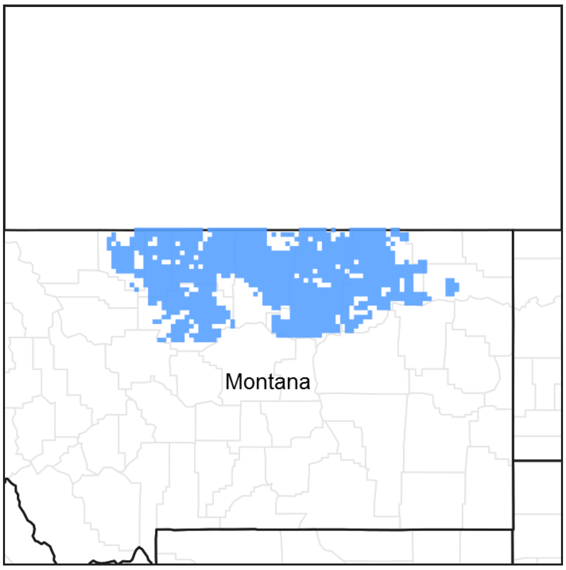

Figure 1. Mapped extent

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 and agriculturally and ecologically significant area. It consists of around 14.5 million acres and stretches across 350 miles from east to west, encompassing portions of 15 counties in north-central Montana. This region represents the southwestern limit of the Laurentide Ice Sheet and is considered to be the driest and westernmost area within the vast network of glacially derived prairie pothole landforms of the northern Great Plains. Elevation ranges from 2,000 feet (610 meters) to 4,600 feet (1,400 meters).

Soils are primarily Mollisols, but Entisols, Inceptisols, Alfisols, and Vertisols are also common. Till from continental glaciation is the predominant parent material, but alluvium and bedrock are also common. Till deposits are typically less than 50 feet thick, and in some areas glacially deformed bedrock occurs at or near the soil surface (Soller, 2001). Underlying sedimentary bedrock largely consisting of Cretaceous shale, sandstone, and mudstone (Vuke et al., 2007) is commonly exposed on hillslopes, particularly along drainageways. Significant alluvial deposits occur along glacial outwash channels and major drainages, including portions of the Missouri, Teton, Marias, Milk, and Frenchman Rivers. Large glacial lakes, particularly in the western half of the MLRA, deposited clayey and silty lacustrine sediments (Fullerton et al., 2013).

Much of the western portion of this MLRA was glaciated towards the end of the Wisconsin age, and the maximum glacial extent occurred approximately 20,000 years ago (Fullerton et al., 2004). The result is a geologically young landscape that is predominantly a level till plain interspersed with lake plains and dominated by soils in the Mollisol and Vertisol orders. These soils are very productive and generally are well suited to dryland farming. Much of this area is aridic-ustic. Crop-fallow dryland wheat farming is the predominant land use. Areas of rangeland typically are on steep hillslopes along drainages.

The rangeland, much of which is native mixedgrass prairie, increases in abundance in the eastern half of the MLRA. The Wisconsin-age till in the north-central part of this area typically formed large disintegration moraines with steep slopes and numerous poorly drained potholes. A large portion of Wisconsin-age till occurring on the type of level terrain that would typically be optimal for farming has large amounts of less-suitable sodium-affected Natrustalfs. Significant portions of Blaine, Phillips, and Valley Counties were glaciated approximately 150,000 years ago during the Illinoisan age. Due to erosion and dissection of the landscape, many of these areas have steeper slopes and more exposed bedrock than areas glaciated during the Wisconsin age (Fullerton and Colton, 1986).

While much of the rangeland in the aridic-ustic portion of MLRA 52 is classified as belonging to the “dry grassland” climatic zone, sites in portions of southern MLRA 52 may belong to the “dry shrubland” climatic zone. The dry shrubland zone represents the northernmost extent of the big sagebrush (Artemisia tridentata) steppe on the Great Plains. As similar soils occur in both southern and northern portions of the MLRA, it is currently hypothesized that climate is the primary driving factor affecting big sagebrush distribution in this area. However, the precise factors are not fully understood at this time.

Sizeable tracts of largely unbroken rangeland in the eastern half of the MLRA and adjacent southern Saskatchewan are home to the Northern Montana population of greater sage-grouse (Centrocercus urophasianus), and large portions of this area are considered to be a Priority Area for Conservation (PAC) by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service, 2013). This population is unique among sage grouse populations in the fact that many individuals overwinter in the big sagebrush steppe (dry shrubland) in the southern portion of the MLRA and then migrate to the northern portion of the MLRA, which lacks big sagebrush (dry grassland), to live the rest of the year (Smith, 2013).

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

Classification relationships

NRCS Soil Geography Hierarchy
• Land Resource Region: Northern Great Plains
• Major Land Resource Area (MLRA) 052: Brown Glaciated Plains
• Climate Zone: Dry Grassland

National Hierarchical Framework of Ecological Units (Cleland et al., 1997; McNab et al., 2007)
• Domain: Dry
• Division: Temperate Steppe
• Province: Great Plains-Palouse Dry Steppe Province 331
• Section: Northwestern Glaciated Plains 331D
• Subsection: Montana Glaciated Plains 331Dh
• Landtype association/Landtype phase: N/A

National Vegetation Classification Standard (Federal Geographic Data Committee, 2008)
• Class: Mesomorphic Shrub and Herb Vegetation Class (2)
• Subclass: Temperate and Boreal Grassland and Shrubland Subclass (2.B)
• Formation: Temperate Grassland, Meadow, and Shrubland Formation (2.B.2)
• Division: Great Plains Grassland and Shrubland Division (2.b.2.Nb)
• Macrogroup: Hesperostipa comata – *Pascopyrum smithii* – Festuca hallii Grassland Macrogroup (2.B.2.Nb.2)
• Group: *Pascopyrum smithii* – Hesperostipa comata – Schizachyrium scoparium – Bouteloua spp. Mixedgrass Prairie Group (2.B.2.Nb.2.c)
• Alliance: *Pascopyrum smithii* – Nassella viridula Northwestern Great Plains Herbaceous Alliance

• Association: *Pascopyrum smithii* –Bouteloua gracilis – Carex filifolia Herbaceous 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) & Glaciated Northern Grasslands (42j)

Ecological site concept

This provisional ecological site occurs in the Dry Grassland climatic zone of MLRA 52. Figure 1 illustrates the distribution of this ecological site based on current data. This map is approximate, is not intended to be definitive, and may be subject to change. Onsite evaluations are necessary, particularly in boundary or intergrade areas where ecological sites from multiple climate zones may overlap. Panspot Dry Grassland is a somewhat extensive ecological site occurring on till plains, moraines, and fans in MLRA 52. This ecological site is especially prevalent on the Malta sublobe in Blaine and Phillips Counties where glacial till is underlain by the Bearpaw Shale Formation. This site is typically associated with Loamy, Panspot, and Thin Claypan ecological sites.

The distinguishing characteristic of this site is the presence of a dense, sodium-affected (natric) horizon at a depth of 1 inch or less from the soil surface. The natric horizon exhibits columnar structure, is very hard, and severely limits both root penetration and infiltration. Soils are typically moderately deep to very deep (greater than 20 inches to bedrock), derived from glacial till, and occur on slopes of less than 8 percent. Soil surface textures (0 to 4 inches) are very fine sandy loam to loam, and the natric horizon is clay or clay loam. Deep-rooted plant species are not well adapted to this site due to the shallow depth of the natric horizon. Species composition is dominated by shallow-rooted short-statured species. Rhizomatous species are subdominant while deep-rooted bunchgrasses are generally absent. Characteristic vegetation is blue grama (Bouteloua gracilis), Sandberg bluegrass (Poa secunda), and western wheatgrass (*Pascopyrum smithii*).

Associated sites

FX052X01X165	**Thin Claypan (Tcp) Dry Grassland** The Thin Claypan site is typically found in complex with this site and is found on micro-highs relative to the Panspot site.
FX052X01X006	**Claypan (Cp) Dry Grassland** The Claypan site is frequently found in complex with this site and is found on micro-highs relative to the Panspot site.
FX052X01X032	**Loamy (Lo) Dry Grassland** The Loamy site is commonly found near this site and is on the highest slope positions relative to the Panspot site.

Similar sites

FX052X03X145	**Panspot (Pn) Dry Shrubland** This site differs from Panspot Dry Grassland in that it has slightly warmer annual temperatures and supports big sagebrush rather than silver sagebrush.
FX052X01X165	**Thin Claypan (Tcp) Dry Grassland** This site differs from the Panspot site in that the root-restricting layer (evidenced by columnar structure) is between 1 inch and 4 inches below the soil surface.
FX052X01X006	**Claypan (Cp) Dry Grassland** This site differs from the Panspot site in that the root-restricting layer (evidenced by columnar structure) is between 4 inches to 10 inches below the soil surface.
FX052X01X032	**Loamy (Lo) Dry Grassland** This site differs from the Panspot site in that the root-restricting layer (evidenced by columnar structure) is either absent or more than 10 inches below the soil surface.

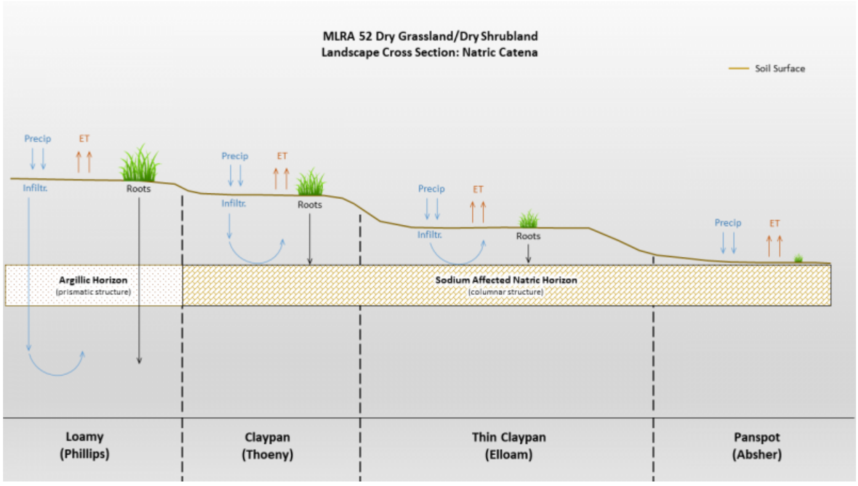

Figure 2. Figure 4. Similar and Associated Sites Diagram.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY145MT

Physiographic features

Panspot Dry Grassland is a common ecological site on moraines, outwash fans, and terraces. This site is moderately extensive across MLRA 52 but is most prevalent on the Malta sublobe, which stretches from southeastern Alberta and southwestern Saskatchewan through northeastern Hill, central Blaine, and southern Phillips Counties. Much of this lobe consists of an extensive ground moraine with slopes of 0 to 4 percent. The till incorporated physical and chemical properties of the underlying clayey Bearpaw Shale, which in MLRA 52 tends to have appreciable amounts of sodium, magnesium, and calcium sulfates but little to no calcium carbonate. It is hypothesized that during and immediately after deglaciation, because of the combination of water-restricting bedrock underlying the sodium-rich clayey till at depths of 10 feet or less and the gentler slopes of the till plain, water could pond and, by matric potential, concentrate enough salts to create the natric horizon and its distinctive columnar structure (Miller and Brierly, 2011). The present-day hydrology of this site lacks a water table. As is the case with the Thin Claypan and Claypan sites, complex microrelief is normal on landforms dominated by natric soils. In relation to the Claypan and Thin Claypan ecological sites, the Panspot site is on microlows. This site is not affected by aspect.

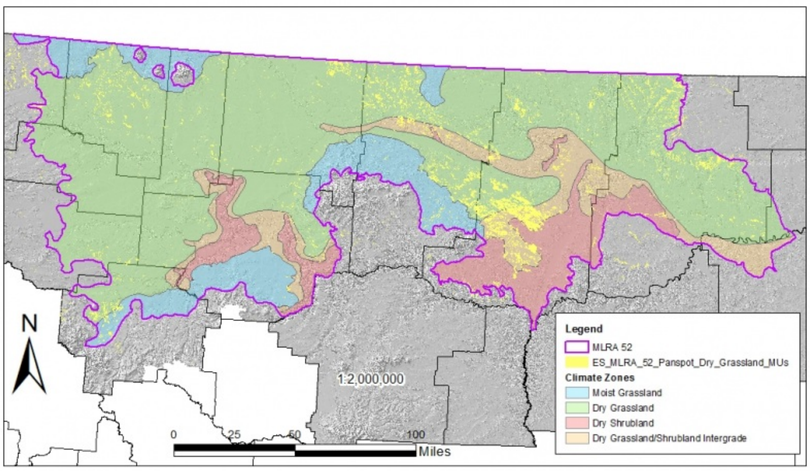

Figure 3. Figure 1. General distribution of the Panspot Dry Grassland ecological site by map unit extent

Table 2. Representative physiographic features

Landforms	(1) Till plain > Moraine (2) Till plain > Fan (3) Terrace
Elevation	2,000–3,870 ft
Slope	0–8%
Aspect	Aspect is not a significant factor

Climatic features

The Brown Glaciated Plains is a semi-arid region with a temperate continental climate that is characterized by frigid winters and warm to hot summers (Cooper et al., 2001). The average frost-free period for this ecological site is 120 days. The majority of precipitation occurs as steady, soaking, frontal system rains in late spring to early summer. Summer rainfall comes mainly from convection thunderstorms that typically deliver scattered amounts of rain in intense bursts. These storms may be accompanied by damaging winds and large-diameter hail and result in flash flooding along low-order streams. Severe drought occurs on average in 2 out of 10 ten years. Annual precipitation ranges from 10 to 14 inches, and 70 to 80 percent of this occurs during the growing season (Cooper et al., 2001). Extreme climatic variations, especially droughts, have the greatest influence on species cover and production (Coupland, 1958, 1961; Biondini et al., 1998).

During the winter months, the western half of MLRA 52 commonly experiences chinook winds, which are strong west to southwest surface winds accompanied by abrupt increases in temperature. The chinook winds are strongest on the western boundary of the MLRA near the Rocky Mountain foothills and decrease eastward. In addition to producing damaging winds, prolonged chinook episodes can result in drought or vegetation kills due to the reaction of plants to a “false spring” (Oard, 1993).

Table 3. Representative climatic features

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

Climate stations used

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

Influencing water features

This site is a dry upland site, but it has unique hydrology because very little moisture can infiltrate through the dense natric horizon, which is 1 inch or less below the soil surface. Infiltration rates on this site are approximately 0.04 inch per hour. In typical precipitation events, most of the moisture is lost through evapotranspiration before it can infiltrate. Abnormally wet years or very intense precipitation events may cause water to pond on the surface or flow laterally via surface runoff onto adjacent sites. Lateral water movement is typically limited to a localized area due to the flat topography of the landscape. The frequency and duration of ponding are not sufficient to assign this site a ponding class, and redoximorphic features are not present.

Soil features

The soil that best represents the central concept of this ecological site is the Absher soil series, which covers over 250,000 acres in MLRA 52. The Absher soil is in the Natrustalfs great group and is characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon and by a dense, root-limiting, non-cemented restrictive layer 1 inch or less below the soil surface. This restrictive layer is referred to as a natric horizon and is essentially an argillic horizon that has been affected by sodium salts. The natric horizon exhibits distinctive columnar structure that is especially visible when the soil is dry. The Absher soil is in a fine family and has smectitic minerology. Clayey till (28 to 42 percent clay) is the typical parent material for this series, but the Panspot site may also occur on soils derived from glaciofluvial and alluvial deposits, shale residuum, or till over residuum. 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. These soils have a frigid soil temperature regime (Soil Survey Staff, 2014).

Surface textures found in this site are most frequently loam but can range from fine sandy loam to silty clay loam and typically contain between 15 to 30 percent clay. The underlying natric horizons typically contain 35 to 50 percent clay and have clay, clay loam, silty clay loam or silty clay textures. Organic matter content in the surface horizon typically ranges from 1 to 2 percent, and moist colors vary from olive brown (2.5Y 4/3) to very dark grayish brown (2.5Y 3/2). The surface horizon of these soils does not typically react with hydrochloric acid. Depth to secondary carbonates and soluble sulfate salts is typically about 5 inches below the soil surface. Calcium carbonate equivalent is typically less than 5 percent in the upper 5 inches and less than 10 percent in lower horizons. Within 20 inches of the surface, electrical conductivity is at some point greater than 4 but less than 16 and the sodium absorption ratio is typically less than 15. These salts lower the amount of plant-available water. Soil pH classes are 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 can be moderately deep (between 20 and 40 inches to bedrock) where bedrock is present but is typically 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. Some areas, particularly in some areas of Phillips and Valley counties, can have more than 35 percent gravel on the surface.

Table 4. Representative soil features

Parent material	(1) Till (2) Glaciofluvial deposits (3) Residuum–shale
Surface texture	(1) Loam (2) Fine sandy loam (3) Silty clay loam
Drainage class	Well drained
Depth to restrictive layer	0–1 in
Soil depth	20–72 in
Available water capacity (0-40in)	2.9–3.4 in
Calcium carbonate equivalent (0-5in)	0–4%
Electrical conductivity (0-20in)	4–15 mmhos/cm
Sodium adsorption ratio (0-20in)	0–14
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), 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 Panspot provisional ecological site in MLRA 52 Dry Grassland consists of four states: The Reference State (1.0), the Altered State (2.0), the Cropland State (3.0), and the Post-Cropland State (4.0). Plant communities associated with this ecological site evolved under the combined influences of climate, grazing, and fire. Extreme climatic variability results in frequent droughts, which have the greatest influence on the relative contribution of species cover and production (Coupland, 1958, 1961; Biondini et al., 1998). Due to the dominance of cool-season graminoids, annual production is highly dependent upon mid- to late-spring precipitation (Heitschmidt and Vermeire, 2005; Anderson, 2006).

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

The historic ecosystem experienced relatively frequent lightning-caused fires with estimated fire return intervals of 6 to 25 years (Bragg, 1995). Historically, Native Americans also set frequent 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 not known how significant fire was on the Panspot ecological site, and further investigation of fire dynamics is needed to better assess this. However, it is hypothesized that fire was infrequent and had little affect due to the high incidence of bare ground and low vegetative production. Non-native annual brome species, such as field, or Japanese, brome (*Bromus arvensis*), 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. Lesser spikemoss, also known as dense clubmoss (*Selaginella densa*), may occur but its dynamics on this site are not well understood.

Drought or improper grazing of this site can result in a reduction in the cover of the perennial grasses and an increase in bare ground, cactus, and annual species. Improper grazing practices include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year and/or that do not provide adequate cover to prevent soil erosion over time. These practices may include, but are not limited to, overstocking, continuous grazing, and/or inadequate seasonal rotation moves over multiple years. Periods of extended drought (approximately 3 years or more) may have similar effects (Coupland, 1958, 1961). Further degradation of the site due to improper grazing can result in a community dominated by cactus and annual forbs. Non-native annual brome grasses may become common in this state. It is hypothesized that annual bromes may at some point dominate the ecological dynamics of this site and result in an invaded state. However, this phenomenon has not been sufficiently documented and the ecological mechanisms are unclear. Further investigation of invasive species dynamics is needed prior to incorporating an invaded state into the state-and-transition model.

Due to the presence of a sodium-affected natric horizon, this ecological site is not generally regarded as productive cropland. Regardless, many acres have been cultivated and planted to cereal grain crops, such as winter wheat, spring wheat, and barley. When taken out of production, this site is either allowed to revert back to perennial grassland or is seeded with introduced species. Sites left to undergo natural plant succession after cultivation are unlikely to return to the Reference State in a reasonable amount of time. Even much more productive sites may take several decades before they can support native vegetation similar to the Reference State (Christian and Wilson, 1999). The Panspot ecological site is likely to take much longer due to the unfavorable physical and chemical soil properties. Natric chemical properties near the soil surface tend to cause these soils to crust following cultivation, therefore making it difficult for vegetation to reestablish naturally. Reestablishment of perennial vegetation may be more successful if the site is reseeded; however, studies have not been conducted on this site specifically. On more productive ecological sites, non-native seedings, particularly crested wheatgrass, may persist indefinitely (Christian and Wilson, 1999). Stand vigor is expected to be less on the Panspot ecological site, but stand longevity is unknown at the time of this writing. Seeding of introduced grasses, particularly crested wheatgrass (*Agropyron cristatum*), was a common practice on eroded and abandoned agricultural areas after the droughts of the 1930s (Rogler and Lorenz, 1983). Crested wheatgrass can invade relatively undisturbed grasslands (Heidinga and Wilson, 2002; Henderson and Naeth, 2005), but its invasion has not been documented on the Panspot ecological site. It is hypothesized that the inhospitable nature of the soil makes it extremely difficult for invasive perennials to establish on the site.

The STM diagram 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 contains two community phases characterized by shortgrasses and rhizomatous wheatgrasses. 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, it was resilient to grazing. Fire was believed to be a minor influence on this site, although fire dynamics are not well understood.

Community Phase 1.1: Shortgrass - Rhizomatous Wheatgrass Phase
The Shortgrass - Rhizomatous Wheatgrass Phase on this site is dominated by shortgrasses with rhizomatous wheatgrasses subdominant. The most dominant species appear to be blue grama and needleleaf sedge. Prairie Junegrass may be present on more favorable areas. Western wheatgrass (*Pascopyrum smithii*) is the most common wheatgrass, although thickspike (*Elymus lanceolatus*) may also occur. Common forbs are woolly plantain (*Plantago patagonica*) and pepperweed (Lepidium spp.). Shrubs and subshrubs include prairie sagewort (*Artemisia frigida*) and winterfat (*Krascheninnikovia lanata*). Plains pricklypear (*Opuntia polyacantha*) commonly occurs at low cover in this phase. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Blue Grama 15%
Needleleaf Sedge 20%
Rhizomatous Wheatgrass 25%
Other Native Graminoids 15%
Native Forbs 5%
Shrubs/Subshrubs 15%
Plains Pricklypear 5%

Estimated Total Annual Production (lbs/ac)*
Low - 50
Representative Value - 150
High - 300
* Estimated based on current data – subject to revision

Community Phase 1.2: Shortgrass Community Phase
The Shortgrass Community Phase is characterized by the elimination or near elimination of rhizomatous wheatgrasses. Shortgrasses, particularly blue grama, are the dominant species. Plains pricklypear is increasing in this phase as well as various annual forbs. The amount of bare ground also begins to increase. As a result, the site is subject to increased erosion and the soil is exposed to increase solar heating.

Community Phase Pathway 1.1a
Drought, improper grazing management, or a combination of these factors can shift the Shortgrass - Rhizomatous Wheatgrass Phase (1.1) to the Shortgrass Community Phase (1.2). These factors favor an increase in shortgrasses and a decrease in midgrasses (Coupland, 1961). Cactus is also likely to increase on this site.

Community Phase Pathway 1.2a
Normal or above-normal spring precipitation and proper grazing management transitions the Shortgrass Community Phase (1.2) back to the Shortgrass - Rhizomatous Wheatgrass 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. Plains pricklypear and annual forbs dominate the plant community.

Transition T1B
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Reference State (1) to the Cropland State (3).

State 2: Altered State
The Altered State consists of one community phase. In the Cactus/Annual Forb Phase (2.1), perennial grasses have been eliminated or nearly so, and their vigor and production are low. The remaining plant community is dominated by plains pricklypear and annual forbs such as woolly plantain. The dynamics of this state are not well understood. This state has a high amount of bare ground. It is hypothesized that this results in increased heating of the soil by solar radiation. The increased heating exacerbates the already dry site conditions and creates a self-perpetuating condition of extreme drought. These extremely dry and hot conditions make it very difficult for perennial species to persist or establish. This hypothesis has not been tested and requires further investigation. Non-native annual bromes are also known to persist in this state. Preliminary observation indicates that their abundance is highly variable and dependent on precipitation patterns and fall germination conditions. It is not known if the bromes alter the site properties sufficiently to transition it to an invaded state.

Community Phase 2.1: Cactus/Annual Forb Phase
In the Cactus/Annual Forb Phase, perennial grasses, such as blue grama, and rhizomatous wheatgrasses have been largely eliminated and replaced by plains pricklypear and annual forbs, such as woolly plantain. The amount of bare ground is high, and the soil is exposed to erosion and solar heating.

Transition T2A
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Reference State (1) to the Cropland State (3).

Restoration Pathway R2A
It is hypothesized that solar heating creates a self-perpetuating condition of extreme drought that suppresses establishment of perennial species. A reduction in livestock grazing pressure alone may not be sufficient to restore the Altered State (2) to the Reference State (1). Intensive management treatments may be necessary (Hart et al., 1985). However, it is not known how well this site responds to practices such as mechanical treatment of grazing land and range seeding. Therefore, returning the Altered State (2) to the Reference State (1) will likely require considerable energy and cost and may not be feasible within a reasonable amount of time.

State 3: Cropland State
The Cropland State (3) occurs when land is put into cultivation. Major crops in MLRA 52 include winter wheat, spring wheat, and barley.

Transition T3A
The transition from the Cropland State (4) to the Post-Cropland State (5) occurs with the cessation of cultivation. The site may also be seeded to perennial forage species. Such seedings may be comprised of introduced grasses and legumes, or a mix of native species.

State 4: Post-Cropland State
The Post-Cropland State (4) occurs when cultivated cropland is abandoned and allowed to either re-vegetate naturally or is seeded back to perennial species for grazing or wildlife use. This state can transition back to the Cropland State (3) if the site is put back into cultivation.

Phase 4.1: Abandoned Cropland Phase
In the absence of active management, the site can re-vegetate naturally and, over time, potentially return to a perennial grassland community with Sandberg bluegrass and blue grama. The chemical properties of the soil surface layers tend to cause crusting on this site following cultivation. As a result, revegetation is likely to take much longer on this site than on a more favorable site, such as Loamy. The first species to establish after cropland is abandoned are typically annual and biennial forbs and annual brome grasses (Samuel and Hart, 1994). At this point, the site is extremely susceptible to erosion due to the absence of perennial species. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses, such as blue grama. Due to tillage breaking up the dense soil structure, it may be possible for perennial bunchgrasses, such as needle and thread, to return; however, this has not been fully evaluated on this site. Cover and production of cool-season rhizomatous wheatgrasses are low, even after several decades (Dormaar and Smoliak, 1985; Dormaar et al., 1994; Christian and Wilson, 1999). Invasion of the site by exotic species, such as crested wheatgrass, and annual bromes will depend upon the site’s proximity to a seed source.

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

Phase 4.2: Perennial Grass Phase
Reestablishment of perennial vegetation may be more successful if the site is reseeded; however, studies have not been conducted on this site specifically. More favorable sites seeded to perennial forage species, particularly introduced perennial grasses, can persist for several decades. Monocultures of crested wheatgrass can persist for at least 60 years (Krzic et al., 2000; Henderson and Naeth, 2005). A mixture of native species may also be seeded. It is possible that tillage operations may have broken up the dense soil structure enough that the Perennial Phase is more productive than the Reference State, but specific data has not been collected. Chemical soil properties would likely still reduce stand vigor and production on this site compared to a Loamy site.

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

State and transition model

Panspot Dry Grassland
R52XY145MT

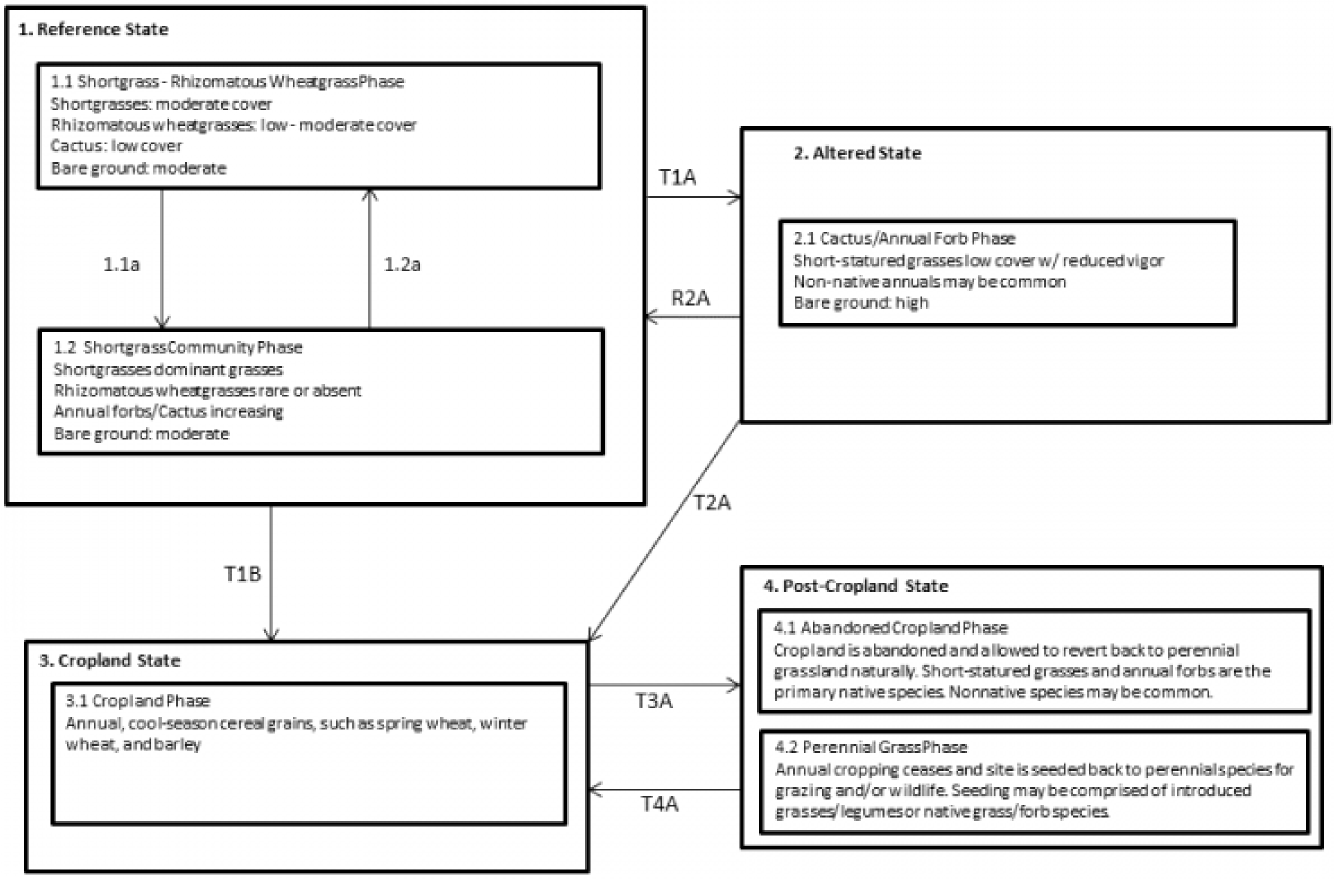

Figure 2. State-and-transition diagram

Panspot Dry Grassland
R52XY145MT

Legend

- 1.1a drought, improper grazing management
- 1.2a normal or above-normal spring moisture, proper grazing management
- T1A prolonged drought, improper grazing, or a combination of these factors
- R2A range seeding, grazing land mechanical treatment, normal or above-normal moisture, proper grazing management (management intensive and costly)
- T1B, T2A, T3A tillage or herbicide followed by seeding of annual crops
- T4A cessation of annual cropping

Figure 3: State-and-transition model legend

Inventory data references

Data for this provisional ecological site was obtained from 2 low-intensity plots representing the Reference State. Two historical (417) sites that were labeled Absher series were also located, but transects were likely a mix of Panspot and Thin Claypan ecological sites. Low-intensity data was collected on an eroded Elloam soil, which is useful for comparison to Panspot but is technically an unfavorable Thin Claypan. Information from these plots was used as a reference to estimate production and species composition for Panspot. Other information is based on professional experience and a review of the scientific literature. All community phases are considered provisional based on these plots and the sources identified in the narratives associated with each community phase.

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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:**