USDA Natural Resources Conservation Service

Ecological site FX052X01X030
Limy (Ly) 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.

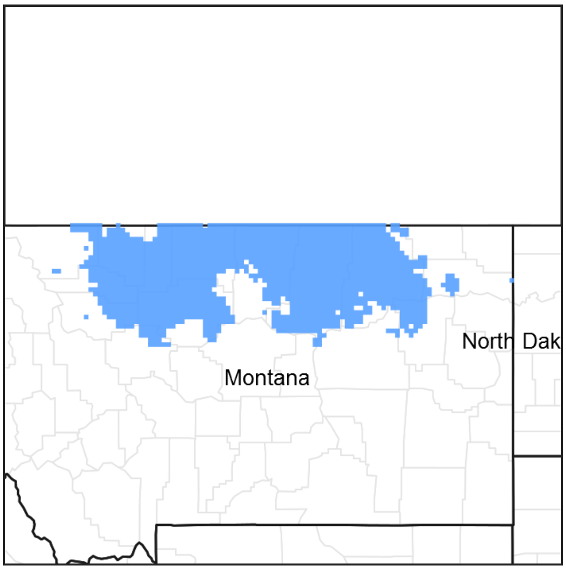

Figure 1. Mapped extent

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, 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 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 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: *Hesperostipa comata - Bouteloua gracilis* Dry Mixedgrass Prairie Group (2.B.2.Nb.2.b)
• Alliance: *Hesperostipa comata* Northwestern Great Plains Herbaceous Alliance (2.B.2.Nb.2.b)
• Association: *Hesperostipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation (2.B.2.Nb.2.b)

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. Limy Dry Grassland is an extensive ecological site occurring on most landscapes in MLRA 52. It occurs on hillslopes, till plains, and bluffs where slopes are less than 15 percent. This site is typically on convex backslopes, shoulders, crests, or summits.

The distinguishing characteristic of this site a relatively young, undeveloped soil profile, which is evidenced by increased calcium carbonate (lime) concentrations in the upper 5 inches and weak soil structure. Soils are typically moderately deep to very deep (more than 20 inches) and derived from glacial till. Soil surface textures are in the fine-loamy textural family. Calcium carbonate equivalent is 5 percent or more (as evidenced by strong or violet effervescence) in the upper 5 inches with $CaCO_3$ concentration and increasing with depth. Characteristic vegetation is needle and thread (*Hesperostipa comata*) and threadleaf sedge (*Carex filifolia*).

Associated sites

FX052X01X029	**Limy-Steep (Lystp) Dry Grassland** This site occurs on steeper slopes (15 percent or greater) adjacent to or downslope from the Limy site. It is generally in backslope positions with a convex slope whereas the Limy site is on shoulders or crests.
FX052X01X040	**Loamy-Steep (Lostp) Dry Grassland** This site occurs on moderate to steeply sloping hillslopes adjacent to or downslope from the Limy Dry Grassland site. It is generally in backslope positions with a linear or concave slope shape.
FX052X01X032	**Loamy (Lo) Dry Grassland** This site is typically adjacent to the Limy site. It is most commonly on summits or base slopes where the slope shape is linear or concave whereas the Limy site is on shoulders or crests where the slope shape is convex.

Similar sites

FX052X03X030	**Limy (Ly) Dry Shrubland** This site differs from Limy Dry Grassland in that it has slightly warmer annual temperatures and supports big sagebrush rather than silver sagebrush.
FX052X01X029	**Limy-Steep (Lystp) Dry Grassland** This site differs from Limy Dry Grassland in that slopes are 15 percent or greater.
FX052X01X032	**Loamy (Lo) Dry Grassland** This site differs from Limy Dry Grassland in that soils contain less than 5 percent calcium carbonate in the upper 5 inches (as evidenced by lack of effervescence).

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY030MT

Physiographic features

Limy Dry Grassland is a common ecological site occurring across the till plains and moraines of MLRA 52. This site is typically in summit and shoulder positions on moraines and hillslopes. These areas have higher runoff potential and drier conditions compared to adjacent sites. Consequently, soil development is weaker, plant production is lower, and soil organic matter is lower.

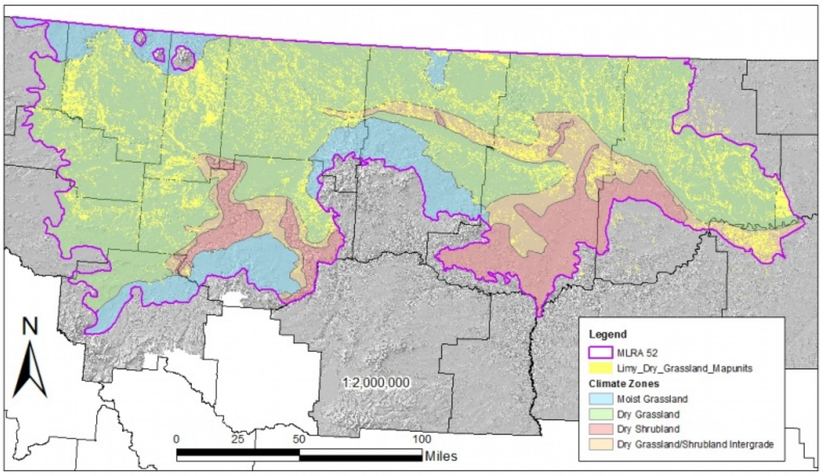

Figure 2. Figure 1. General distribution of the Limy Dry Grassland ecological site by map unit extent.

Table 2. Representative physiographic features

Hillslope profile	(1) Summit (2) Shoulder
Landforms	(1) Till plain > Moraine (2) Till plain > Hillside
Elevation	610–1,180 m
Slope	0–14%
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)	305 mm

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 not influenced by a ground water table or other soil hydrology. Moisture loss through potential evapotranspiration exceeds precipitation for the majority of the growing season. With the exception of May and June, the site is generally in a state of moisture deficit.

Soil features

The Hillon series is the soil that best represents the central concept for this ecological site, but only when it occurs on slopes less than 15 percent. This concept occurs on more than 320,000 acres of MLRA 52, but Hillon soil also occurs on the Limy Steep Dry Shrubland ecological site. This soil formed in calcareous till and is currently misclassified as a fine-loamy, mixed, superactive, calcareous, frigid Aridic Ustorthents in the Official Series Description database. The correct classification is a Fine-loamy, mixed, superactive, frigid Aridic Haplustepts. This soil is characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon and by weakly developed sub-surface soil horizons. The Hillon series is in the fine-loamy family, meaning it contains between 18 and 35 percent clay in the particle-size control section, and has mixed minerology. The typical parent material, for this series is calcareous glacial till, but this ecological site may also occur on soils derived from glaciofluvial deposits, or till over residuum. The soil moisture regime for this and all other soils in this ecological site concept is ustic bordering on aridic, which means that the soils are moist in some or all parts for either 180 cumulative days or 90 consecutive days during the growing season but are dry in some or all parts for over 90 cumulative days. These soils have a frigid soil temperature regime (Soil Survey Staff, 2014).

Surface textures found in this site are most frequently loam or clay loam and typically contain between 18 to 35 percent clay. The underlying horizons typically contain 18 to 35 percent clay and also have loam or clay loam 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). Calcium carbonate equivalent in the upper 5 inches of soil is 5 percent or more and typically increases with depth. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH is slightly to moderately alkaline in the surface horizon and moderately to strongly alkaline in the subsurface horizons. The soil depth class for this site can be moderately deep (> 20 inches) in places 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 typically less than 15 percent.

Table 4. Representative soil features

Parent material	(1) Till (2) Glaciofluvial deposits
Surface texture	(1) Loam (2) Clay loam
Drainage class	Well drained
Soil depth	51–183 cm

Available water capacity (0-101.6cm)	14.99–17.53 cm
Calcium carbonate equivalent (0-12.7cm)	5–10%
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)	7.4–9
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), 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 Limy provisional ecological site in MLRA 52 Dry Grassland consists of five states: The Reference State (1.0), the Shortgrass State (2.0), the Invaded State (3.0), the Cropland State (4.0), and the Post-Cropland State (5.0). Plant communities associated with the Limy 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 (Antilocarpa 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; Lockwood, 2004) also played an important role in the ecology of these communities.

The historic ecosystem also 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). Generally, the mixedgrass ecosystem is resilient to fire and the historic fire return interval had neutral or slightly positive effects on the plant community (Vermeire et al., 2011, 2014). However, studies have shown that shorter fire return intervals can have a negative effect, shifting species composition toward warm-season, short-statured grasses (Shay et al., 2001; Smith and McDermid, 2014). Conversely, long-term fire suppression in the 20th century removed periodic fire from the ecosystem altogether. Lack of periodic fires can result in an increase in litter accumulation and, in some cases, provided ideal conditions for seed germination and seedling establishment of non-native annual brome species, such as field, or Japanese, brome (Bromus japonicus; 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.

Improper grazing of this site can result in a reduction in the cover of the cool-season midgrasses and eventually a decrease in other cool-season graminoids and an increase in blue grama (Smoliak et al., 1972; Smoliak, 1974). Periods of extended drought can reduce mid-statured, cool-season grasses and shift the species composition of this community to one dominated by blue grama (Coupland, 1958, 1961). Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as blue grama and Sandberg bluegrass. Cover of mid-statured grasses and sedges is severely reduced or absent. Cover of prairie sagewort can increase.

Due to the increased concentration of calcium carbonate near the soil surface and the weakly developed soil profile, 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, the 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 can, over several decades, support native vegetation similar to the Reference State (Christian and Wilson, 1999), although it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar and Willms, 1990). However, those sites seeded with non-native species, particularly crested wheatgrass, may persist with this cover type indefinitely (Christian and Wilson, 1999).

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 mid-statured, cool-season bunchgrasses and threadleaf sedge (*Carex filifolia*), 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. In general, this state was resilient to grazing and fire, although these factors could influence species composition in localized areas.

Phase 1.1: Mixedgrass Community Phase
The Mixedgrass Community Phase is dominated by needle and thread (*Hesperostipa comata*) and threadleaf sedge. The rhizomatous species western wheatgrass (*Pascopyrum smithii*) is not as prevalent as on associated sites, and its composition by weight is generally 10 percent or less. Short-statured, cool-season grasses, such as prairie Junegrass (*Koeleria macrantha*) and Sandberg bluegrass (*Poa secunda*), are common although cover and production are low. Prairie Junegrass and plains muhly (*Muhlenbergia cuspidata*) appear to become more common as clay content in the soil increases. The mat-forming, warm-season perennial grass blue grama (*Bouteloua gracilis*) is also an important component of this site, sometimes as a subdominant component of the plant community. Common forbs are scarlet globemallow (*Sphaeralcea coccinea*) and spiny phlox (*Phlox hoodii*). Shrubs and subshrubs are not abundant on this site; however, the subshrubs prairie sagewort (*Artemisia frigida*) and winterfat (*Krascheninnikovia lanata*) commonly occur at low cover. Dense spikemoss (*Selaginella densa*), also known as dense clubmoss, is typically absent on this site. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Needle and Thread 30%
Threadleaf Sedge 30%
Blue Grama 5-15%
Western Wheatgrass 5-10%
Other Native Grasses 5-10%
Perennial Forbs 1-5%
Shrubs/Subshrubs 1-5%

Estimated Total Annual Production (lbs/ac)*
Low - 350
Representative Value - 550
High - 750
* Estimated based on current data – subject to revision

Phase 1.2: At Risk Community Phase
The At Risk Community Phase is characterized by a sedge-shortgrass plant community. Sedges and shortgrasses (commonly threadleaf sedge and blue grama) co-dominate the plant community while needle and thread is reduced to a subdominant or minor role. Other shortgrass species that increase in this phase include prairie Junegrass and Sandberg bluegrass. The rhizomatous species western wheatgrass becomes rare and is nearly eliminated in this phase. Bare ground increases in extent, making the site more susceptible to erosion by wind and water.

Community Phase Pathway 1.1a
Drought, improper grazing management, multiple fires in close succession, or a combination of these factors can shift the reference community phase (1.1) to the At Risk Community Phase (1.2). These factors favor an increase in blue grama and a decrease in cool-season midgrasses (Coupland, 1961; Shay et al., 2001).

Community Phase Pathway 1.2a
The At Risk Community Phase (1.2) can return to the reference community phase (1.1) with normal or above-normal spring precipitation and proper grazing management.

Transition T1A
The Reference State (1) transitions to the Shortgrass State (2) when mid-statured graminoids become rare and contribute little to production. Shortgrasses, particularly the warm-season, mat-forming blue grama, dominate the plant community. Threadleaf sedge cover is reduced, and vigor is low. 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).

Transition T1B
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). Crested wheatgrass, in particular, is a concern when native plant communities are adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses (Henderson and Naeth, 2005) and soil quality (Smoliak and Dormaar, 1985; Dormaar et al., 1995), have been substantially altered from the Reference State.

Transition T1C
The Reference State (1) will transition to the Cropland State (4) when the site is placed into cultivation with crops such as winter wheat, spring wheat, and barley.

State 2: Shortgrass State
The Shortgrass State 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 Shortgrass Community Phase (2.1) is dominated by short-statured grasses such as blue grama. Mid-statured grasses have been eliminated or nearly so while vigor and production of threadleaf sedge is declining.

Phase 2.1: Shortgrass Community Phase
In the Shortgrass Community Phase, needle and thread has been largely eliminated and replaced by short-statured species, such as blue grama, prairie Junegrass, and Sandberg bluegrass. Threadleaf sedge has been reduced to a subdominant or minor component with declining vigor and production. Prairie sagewort may also increase in this phase. There is a high amount of bare ground, and erosional patterns and plant pedestaling are evident.

Transition T2A
The Shortgrass State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade the Shortgrass State (2). Crested wheatgrass, in particular, is a concern when native plant communities are adjacent to seeded pastures. Exotic plant species dominate the site in terms of cover and production. Site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses (Henderson and Naeth, 2005) and soil quality (Smoliak and Dormaar, 1985; Dormaar et al., 1995), have been substantially altered from the Reference State.

Transition T2B
The Shortgrass State (2) will transition to the Cropland State (4) when the site is placed into cultivation with crops such as winter wheat, spring wheat, and barley.

Restoration Pathway R2A
Blue grama can resist displacement by other species (Dormaar and Willms, 1990; Laycock, 1991; Dormaar et al., 1994; Lacey et al., 1995). A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of blue grama in the Shortgrass State (3) (Dormaar and Willms, 1990) and mechanical treatments may be necessary (Hart et al., 1985). Therefore, returning the Shortgrass State (2) to the Reference State (1) can require considerable cost, energy, and time.

State 3: Invaded State
The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Crested wheatgrass, in particular, is a concern when native plant communities are adjacent to seeded pastures. An estimated 20 million acres of crested wheatgrass have been planted in the western U.S. (Holechek, 1981). Crested wheatgrass produces abundant seeds that can dominate the seed bank of invaded grasslands (Henderson and Naeth, 2005), although crested wheatgrass cover decreases with increasing distance from seeded areas (Heidinga and Wilson, 2002). The early growth of crested wheatgrass allows this species to take advantage of early season soil moisture, which may result in competitive exclusion of native cool-season rhizomatous wheatgrasses and bunchgrasses, such as needle and thread and prairie Junegrass (Christian and Wilson, 1999; Heidinga and Wilson, 2002; Henderson and Naeth, 2005). Reduced soil quality (Dormaar et al., 1995), reduced plant species diversity, and simplified structural complexity (Henderson and Naeth, 2005) result in a state that is substantially departed from the Reference State (1).

Noxious weeds such as leafy spurge are uncommon on this site, but they may also invade and displace native species. Although very aggressive, these species can sometimes be suppressed through intensive management (herbicide application, biological control, or intensive grazing management). Control efforts are unlikely to eliminate noxious weeds, but their density can be sufficiently suppressed so that species composition, structural complexity, and soil quality are similar to that of the Reference State (1). However, cessation of control methods will most likely result in recolonization of the site by the noxious species.

Transition T3A
The Invaded State (3) will transition to the Cropland State (4) when the site is placed under cultivation.

State 4: Cropland State
The Cropland State (4) occurs when land is put into cultivation. Major crops in MLRA 52 include winter wheat, spring wheat, and barley.

Transition T4A
The transition from the Cropland State (4) to the Post-Cropland State (5) occurs with the cessation of cultivation. The site may also be seeded to perennial forage species, such as crested wheatgrass and alfalfa, or a mix of native species.

State 5: Post-Cropland State
The Post-Cropland State (5) occurs when cultivated cropland is abandoned and allowed to either re-vegetate naturally or is seeded back to perennial species for grazing or wildlife use. This state can transition back to the Cropland State (4) if the site is put back into cultivation.

Phase 5.1: 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 needle and thread and blue grama. Shortly after cropland is abandoned, annual and biennial forbs and annual brome grasses invade the site (Samuel and Hart, 1994). The site is highly 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 Sandberg bluegrass and blue grama. Depending on the historical management of the site, perennial bunchgrasses such as needle and thread may also return; however, species composition will depend upon the seed bank. Cover and production of cool-season rhizomatous wheatgrasses is 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 5.2: Pasture Phase
When the site is seeded to perennial forage species, particularly perennial grasses such as crested wheatgrass, this community phase can persist for several decades. Monocultures of crested wheatgrass can persist for at least 60 years (Krzic et al., 2000; Henderson and Naeth, 2005). A mixture of native species may also be seeded to provide species composition and structural complexity similar to that of the contemporary reference state (2). However, soil quality conditions have been substantially altered and will not return to pre-cultivation conditions within a reasonable timeframe (Dormaar et al., 1990).

Transition 5A
The Post-Cropland State (5) transitions back to the Cropland State (4) when the site is converted to cropland.

State and transition model

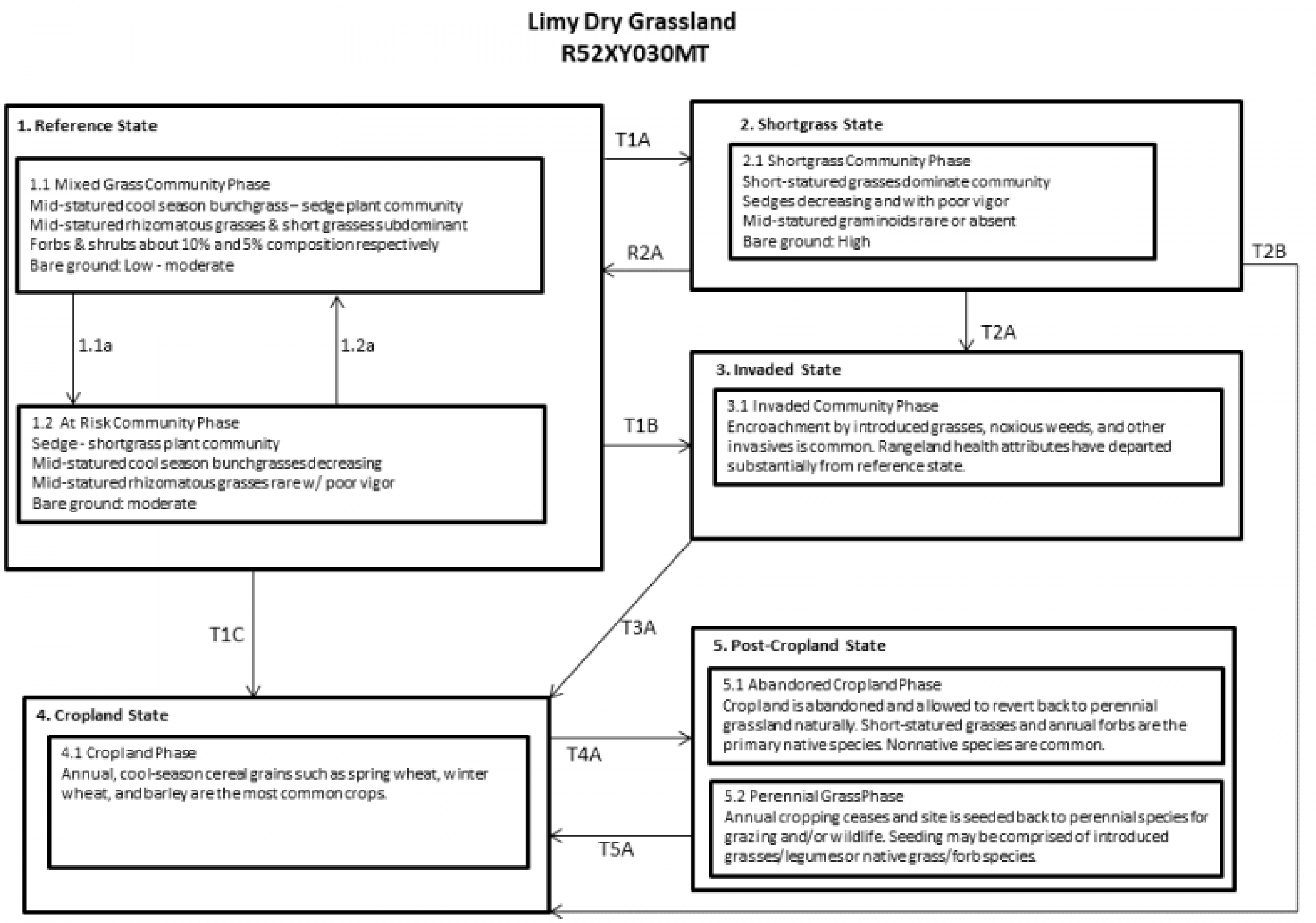

Figure 2. State-and-transition diagram.

Limy Dry Grassland
R52XY030MT

Legend

- 1.1a drought, improper grazing management, multiple fires in close succession
- 1.2a timely moisture, proper grazing management
- T1A prolonged drought, improper grazing, or a combination of these factors
- T1B introduction of non-native invasive species (crested wheatgrass, noxious weeds, etc.)
- T2A introduction of weedy species; combined with drought and/or improper grazing management
- R2A range seeding, grazing land mechanical treatment, timely moisture, proper grazing management (management intensive and costly)
- T1C, T2B, T3A, T5A conversion to cropland
- T4A cessation of annual cropping

Inventory data references

Data for this provisional ecological site was obtained from a total of 6 plots of Tier 1 and Tier 2 intensity. The Reference State (1) was represented by one Tier 2 and three Tier 1 plots. The Shortgrass State (2) was represented by two Tier 1 plots. 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):**

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14. **Average percent litter cover (%) and depth (in):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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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:**

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17. **Perennial plant reproductive capability:**
