

Ecological site FX052X01X012 Dense Clay Sodic (Dcsd) 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.

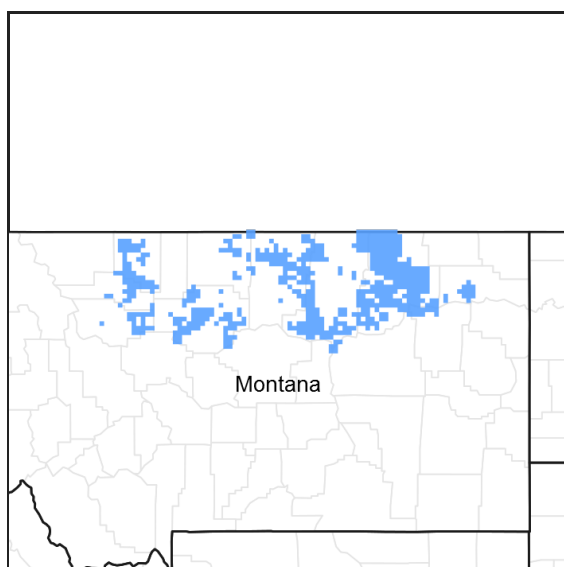


Figure 1. Mapped extent

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

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

While much of the rangeland in the aridic-ustic portion of MLRA 52 is classified as belonging to the “dry grassland” climatic zone, sites in portions of southern MLRA 52 may belong to the “dry shrubland” climatic zone. The dry shrubland 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 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 because many individuals overwinter in the big sagebrush steppe (dry shrubland) in the southern portion of the MLRA and then migrate to the northern portion of the MLRA, which lacks big sagebrush (dry grassland), to live the rest of the year (Smith, 2013).

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

Classification relationships

NRCS Soil Geography Hierarchy

- Land Resource Region: Northern Great Plains
- Major Land Resource Area (MLRA): 052 Brown Glaciated Plains
- Climate Zone: Dry 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* Mixedgrass Prairie Group (2.B.2.Nb.2.c)
- Alliance: No existing correlation

- Association: No existing correlation

EPA Ecoregions

- Level 1: Great Plains (9)
- Level 2: West-Central Semi-Arid Prairies (9.3)
- Level 3: Northwestern Glaciated Plains (42)
- Level 4: North Central Brown Glaciated Plains (42o) & 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. Dense Clay Sodic Dry Grassland is a moderately extensive ecological site occurring on alluvial landscapes throughout MLRA 52. It occurs on fans, drainageways, and terraces where clay and salts have accumulated.

The distinguishing characteristic of this site is that soils contain more than 35 percent clay in the upper 4 inches and that saline, sodic, or saline-sodic conditions are evident in the upper 20 inches of soil. Soils for this ecological site are typically very deep (more than 60 inches) and derived from clayey glaciolacustrine or outwash deposits. Soil textures in the upper 4 inches are typically clay, clay loam, silty clay or silty clay loam. Soils typically have an ochric epipedon. Characteristic vegetation is western wheatgrass (*Pascopyrum smithii*) and Gardner's saltbush (*Atriplex gardneri*). The principal sagebrush species on this site is silver sagebrush (*Artemisia cana*), which typically only occurs at low cover.

Associated sites

FX052X01X094	Loamy Sodic (Losd) Dry Grassland Loamy Sodic Dry Grassland is on similar landscapes and slope positions as Dense Clay Sodic Dry Grassland but in areas where clay content is 35 percent or less.
FX052X99X091	Saline Overflow (Sov) Saline Overflow Dry Grassland is downslope from the Dense Clay Sodic site. It typically is in perennial or intermittent drainages whereas the Dense Clay Sodic site occurs in upland or ephemeral drainageways.

Similar sites

FX052X03X012	Dense Clay Sodic (Dcsd) Dry Shrubland This site differs from Dense Clay Sodic Dry Grassland in that it has slightly warmer annual temperatures and can support big sagebrush.
FX052X01X094	Loamy Sodic (Losd) Dry Grassland This site differs from Dense Clay Sodic Dry Grassland in that soils contain 35 percent or less clay in the upper 4 inches.
FX052X99X091	Saline Overflow (Sov) This site differs from Dense Clay Sodic Dry Grassland in that Saline Overflow is found on higher order stream reaches and receives enough additional moisture to significantly increase production, whereas the Dense Clay Sodic site occurs in uplands or ephemeral drainageways and does not receive enough additional moisture to increase production.
FX052X01X010	Dense Clay (DC) Dry Grassland This site differs from Dense Clay Sodic Dry Grassland in that soils do not exhibit saline, sodic, or saline-sodic conditions in the upper 20 inches of the profile. This is evidenced by the lack of sodium-tolerant shrubs, such as saltbush and greasewood.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY012MT

Physiographic features

Dense Clay Sodic Dry Grassland is a moderately extensive ecological site occurring on fans, drainageways, terraces, and lake plains. This site is not affected by aspect.

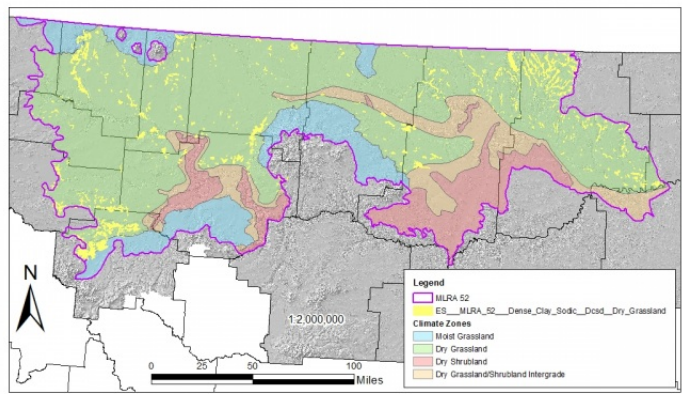


Figure 2. Figure 1. General distribution of the Dense Clay Sodic Dry Grassland ecological site by map unit extent

Table 2. Representative physiographic features

Landforms	(1) Fan (2) Drainageway (3) Terrace (4) Lake plain
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
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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 is a dry upland site and the water budget is normally contained within the soil profile. During intense precipitation events, precipitation rates frequently exceed infiltration rates and this site delivers moisture to downslope sites via surface runoff. Moisture loss through evapotranspiration exceeds precipitation for the majority of the growing season. Soil moisture levels are greatest in May and June, but rarely reach field capacity in the upper 40 inches.

Soil features

The soil series that best represent the central concept for this ecological site are Marvan and Vanda. The Dense Clay Sodic concept covers about 325,000 acres in MLRA 52. The Marvan soil is in the Haplusterts great group. Its underlying horizons exhibit strong shrink-swell characteristics, as evidenced by slickensides (USDA-NRCS, 2016). The Vanda soil is in the Ustorthents great group. Its underlying horizons exhibit some shrink-swell properties but do not exhibit slickensides. The particle-size family for both of these soils is fine, meaning that the soils contain between 35 and 60 percent clay in the particle-size control section, and mineralogy is smectitic. The typical parent material for these series is clayey alluvium. These and all soils in this concept are characterized by an accumulation of salts in the upper 20 inches and a surface horizon that lacks enough organic matter to have a mollic epipedon. 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 horizon textures on this site are commonly clay, clay loam, or silty clay loam. The upper 4 inches of soil contains more than 35 percent clay. The underlying horizons typically contain 35 to 60 percent clay and have clay, clay loam, silty clay or silty clay loam textures. Organic matter in the surface horizon typically ranges from 0.5 to 2 percent organic matter, and moist colors vary from grayish brown (2.5Y 5/2) to dark grayish brown (2.5Y 4/2). Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. The upper 20 inches of soil contain accumulated salts, as evidenced by an electrical conductivity of 4 or more, a sodium absorption ratio of 13 or more, or both. 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 is site can be moderately deep (between 20 and 40 inches to bedrock) in places where bedrock is present but is typically very deep (greater than 60 inches to bedrock). Coarse fragments are typically rare or absent in the upper 20 inches of soil.

Table 4. Representative soil features

Parent material	(1) Alluvium
Surface texture	(1) Clay (2) Clay loam (3) Silty clay loam

Drainage class	Well drained
Soil depth	51–183 cm
Available water capacity (0-101.6cm)	10.16–14.73 cm
Calcium carbonate equivalent (0-12.7cm)	0–14%
Electrical conductivity (0-50.8cm)	4–16 mmhos/cm
Sodium adsorption ratio (0-50.8cm)	13–40
Soil reaction (1:1 water) (0-101.6cm)	5.6–9
Subsurface fragment volume <=3" (0-50.8cm)	0–14%
Subsurface fragment volume >3" (0-50.8cm)	0–14%

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 Dense Clay Sodic 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 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. American 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 periodic fires. The majority of lightning-caused fires occurred in July and August, whereas Native Americans typically set fires during spring and fall to correspond with the movement of bison (Higgins, 1986). 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). It is not known how significant fire was on the Dense Clay Sodic ecological site. It is believed that the frequency and intensity of fire would be less than that of adjacent sites due to the sparse vegetative cover. Further investigation of fire dynamics is needed to better assess this. Nonnative annual bromes have become naturalized in relatively undisturbed grasslands (Ogle et al., 2003; Harmoney, 2007). They can be present in any state within the scope of this ecological site, but their abundance varies depending on precipitation and germination conditions. They typically are not abundant enough to have a significant ecological impact. However, in the Invaded State, they may be abundant enough to do so. Further study is required to assess this.

Improper grazing of this site can result in a reduction in the cover of the mid-statured cool-season, rhizomatous wheatgrasses and an increase in shortgrasses (Smoliak et al., 1972; Smoliak, 1974). Improper grazing practices

include any practices that do not allow sufficient opportunity for plants to physiologically recover from a grazing event or multiple grazing events within a given year and/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) can reduce mid-statured cool-season, rhizomatous wheatgrasses, triggering an increase in shortgrasses such as Sandberg bluegrass (Coupland, 1961; Clarke et al., 1947).

Further degradation of the site due to improper grazing can result in a community dominated by shortgrasses such as Sandberg bluegrass. Cover and vigor of mid-statured rhizomatous grasses and palatable shrubs are severely reduced. Unpalatable forbs such as curlycup gumweed (*Grindelia squarrosa*) are common. Cover of foxtail barley (*Hordeum jubatum*) can also increase. Invasive species such as curly dock (*Rumex crispus*), crested wheatgrass (*Agropyron cristatum*), and non-native annual bromes have been documented on this site, but they do not tend to dominate it. It is unknown if they significantly alter ecological dynamics. An invaded state is hypothesized, but further investigation is needed to fully document ecological pathways and processes.

The Dense Clay Sodic Dry Grassland ecological site is poorly suited to cropland. Regardless, many acres have been converted to cropland. Cereal grains such as wheat and barley are, at best, marginally successful on this site. Crop production typically ceases within a few years due to low yields and large input costs. Typically, cropping operations are directed at increasing perennial hay production. Seeding of introduced grasses for hay production may be successful, particularly if salt-tolerant species such as RS, or hybrid, wheatgrass (*Elymus hoffmannii*) are used. Irrigation is sometimes used in an effort to increase production, but this site is poorly suited to irrigation practices due to accumulated salts and very low intake rates.

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 cool-season rhizomatous wheatgrasses, although cover and production of these species are lower than in the Reference State. Those sites seeded with non-native species, particularly salt-tolerant grasses, may persist with this cover type indefinitely. When reseeded to native species, it may take over 75 years for the soil on productive sites to return to the pre-disturbed state (Dormaer and Willms, 1990). The Dense Clay Sodic site may take longer due to the difficult growing conditions. Further investigation is needed to better evaluate this.

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. 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. Vegetation is characterized by mid-statured cool-season rhizomatous grasses, salt-tolerant deciduous shrubs, and short-statured grasses.

Community Phase 1.1: Rhizomatous Wheatgrass/Saltbush Phase

The Rhizomatous Wheatgrass/Saltbush Phase is typically dominated by western wheatgrass and Gardner saltbush (*Atriplex gardneri*). Thickspike wheatgrass may also be present, becoming abundant in the northern extent of this ecological site. Palatable shrubs such as Gardner saltbush, fourwing saltbush (*Atriplex canescens*), and winterfat (*Krascheninnikovia lanata*) are common. Short-statured grasses such as Sandberg bluegrass (*Poa secunda*) are not abundant in this phase but are generally present at low cover. Foxtail barley and greasewood (*Sarcobatus vermiculatus*) may also be present at low cover. Common forbs are American vetch (*Vicia americana*) and scarlet globemallow (*Sphaeralcea coccinea*). Silver sagebrush (*Artemisia cana*) is the predominant sagebrush species and is present in trace amounts. The approximate species composition of the reference plant community is as follows:

Percent composition by weight*

Rhizomatous Wheatgrass 50%
Sandberg bluegrass 5%
Other Native Grasses 15%
Perennial Forbs 10%
Gardner Saltbush 10%
Winterfat 5%
Other Native Shrubs/Subshrubs 5%

Estimated Total Annual Production (lbs/ac)*

Low - 150

Representative Value - 300

High - 450

* Estimated based on current data – subject to revision

Community Phase 1.2: At-Risk Community Phase

In the At-Risk Community Phase, rhizomatous wheatgrasses are in decline and are in nearly equal proportion to shortgrasses. Shortgrasses such as Sandberg bluegrass are increasing as are unpalatable forbs such as curlycup gumweed. Palatable shrubs are being browsed and beginning to decline in vigor in this phase.

Community Phase Pathway 1.1a

Drought, improper grazing management, or a combination of these factors can shift the Rhizomatous Wheatgrass/Saltbush Phase (1.1) to the At-Risk Community Phase (1.2). These factors favor a decrease in cool-season midgrasses and an increase in shortgrasses (Coupland, 1961).

Community Phase Pathway 1.2a

The At-Risk Community Phase (1.2) can return to the Rhizomatous Wheatgrass/Saltbush Phase (1.1) with normal or above-normal spring precipitation and proper grazing management.

Transition T1A

Improper grazing practices, prolonged drought (approximately 3 years or more), or a combination of these factors weaken the resilience of the Reference State (1) and drive its transition to the Shortgrass State (2). The Reference State transitions to the Shortgrass State when cool-season rhizomatous wheatgrasses become rare and contribute little to production. Shortgrasses, particularly Sandberg bluegrass, and unpalatable forbs dominate the plant community.

Transition T1B

The Reference State (1) transitions to the Invaded State (3) when invasive plant species invade the Reference State (1). These communities are commonly 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 and soil quality, have been substantially altered from the Reference State.

Transition T1C

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

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 site is dominated by shortgrasses while rhizomatous wheatgrasses have been eliminated or nearly so. Heavy browsing of palatable shrubs is common. Production of these species is low, and vigor is poor. Unpalatable forbs are common and may account for as much as 50 percent of the total annual production. Reductions in stocking rates can reduce shortgrass cover and increase the cover of rhizomatous wheatgrasses. This recovery may take decades, especially if soil properties are substantially altered (Dormaar and Willms, 1990).

Community Phase 2.1: Shortgrass Community Phase

The Shortgrass Community Phase is dominated by shortgrasses such as Sandberg bluegrass. Palatable shrubs, such as Gardner saltbush and winterfat, are rare and have poor vigor. Unpalatable forbs such as curlycup

gumweed are common and may account for as much as 50 percent of the total production. Foxtail barley may also become common in this phase.

Transition T2A

The Reference State (1) transitions to the Invaded State (3) when invasive plant species invade the Reference State (1). These communities are commonly 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 and soil quality, have been substantially altered from the Reference State.

Transition T2B

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Shortgrass State (2) to the Cropland State (4).

Restoration Pathway R2A

Reduction in livestock grazing pressure alone may not be sufficient to restore the Shortgrass State (2) to the Reference State (1) (Dormaer and Willms, 1990). Practices such as range seeding may be necessary (Hart et al., 1985), but these are management intensive and costly. Therefore, returning the Shortgrass State (2) to the Reference State (1) can require considerable energy and cost and may not be feasible within a reasonable amount of time.

State 3: Invaded State

The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Field brome (*Bromus arvensis*) is a common species, but it is not known how severely it alters ecological site dynamics. Crested wheatgrass and curly dock have been documented on this site but do not appear to dominate the plant community. Noxious weeds such as leafy spurge have not been documented on this site. These species are very aggressive; they typically displace native species and dominate ecological function when they invade a site. Further study is needed to fully assess the ecological dynamics of the Invaded State.

Transition T3A

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

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. This site is poorly suited to crops, and cereal grain production is generally short lived.

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 seedings may be comprised of introduced grasses and legumes, 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 western wheatgrass and Sandberg bluegrass. Shortly after cropland is abandoned, annual forbs, biennial forbs, and foxtail barley invade the site. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses. Invasion of the site by exotic species, such as curly dock, 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 (Dormaer and Smoliak, 1985), making a shift to the Reference State (1) is unlikely within a reasonable timeframe.

Phase 5.2: Perennial Grass Phase

When the site is seeded to perennial forage species, particularly perennial grasses such as RS, or hybrid, wheatgrass, this community phase can persist for several decades. This phase is typically managed for hay production and may occur in conjunction with irrigation or water spreading practices. This site is poorly suited to irrigation due to slow intake rates and salt accumulations. Water spreading structures will permanently alter the hydrology of the site. A mixture of native species may also be seeded to provide species composition and structural complexity similar to that of the Reference State (1). However, the site is unlikely to return to pre-cultivation conditions within a reasonable timeframe, particularly if irrigation or water spreading is applied.

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

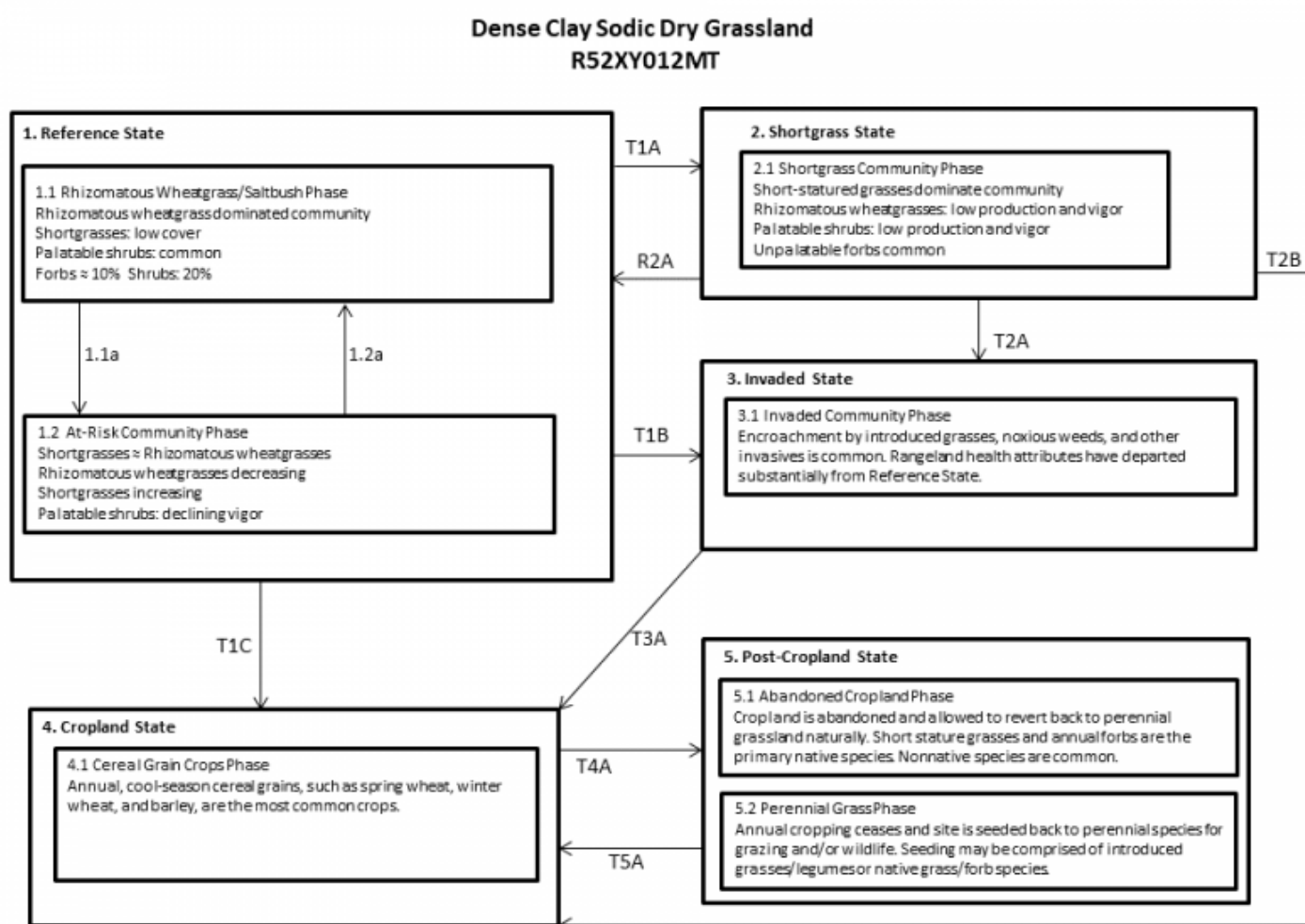


Figure 2. State-and-transition diagram

**Dense Clay Sodic Dry Grassland
R52XY012MT**

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
- T1B introduction of non-native invasive species
- T2A introduction of weedy species; combined with drought and/or improper grazing management
- R2A range seeding, normal or above-normal moisture, proper grazing management
(management intensive and costly)
- T1C, T2B, T3A, T5A conversion to cropland
- T4A cessation of annual cropping

Figure 3. State-and-transition legend

Inventory data references

No specific field data was available for this site. One medium-intensity plot and 2 historical (417) plots were available for the Dense Clay Sodic Dry Shrubland site and were used in conjunction with available literature to approximate the reference plant community for this provisional ecological site. Information for alternate states was obtained from 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:**
