USDA Natural Resources Conservation Service

Ecological site FX052X01X062
Swale (Se) 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.

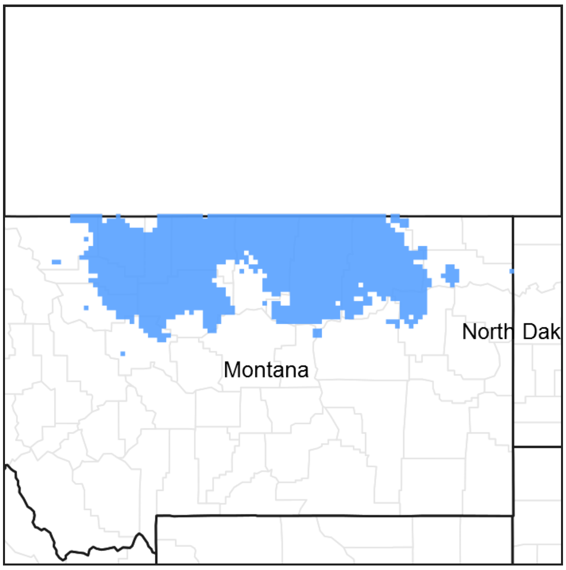

Figure 1. Mapped extent

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 – Nassella viridula 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. Map units shown in Figure 1 contain minor components of this ecological site, typically less than 10 percent of the map unit composition. 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. Swale Dry Grassland is an extensive ecological site on till plains, moraines, and fans in MLRA 52. Although present in the vast majority of soil map units, it is nearly always a minor component because it occurs on swale microfeatures. A swale is defined as a shallow, open depression in unconsolidated materials which lacks a defined channel but can funnel overland or subsurface flow into a drainageway (USDA-NRCS, 2016).

The distinguishing characteristic of this site is that it receives additional moisture via surface runoff from adjacent sites. Soils for this ecological site may range from moderately deep (between 20 to 40 inches to bedrock) to very deep (greater than 60 inches to bedrock), but are typically very deep and derived from local alluvium. This ecological site may occur on slopes of up to 15 percent, but most commonly occurs on slopes of 8 percent or less. Soil surface textures (0 to 4 inches) are typically loam to clay loam. In some areas, but not all, the soils have a mollic epipedon. This site is more productive than surrounding sites due to the increased available moisture. Characteristic vegetation is green needlegrass (Nassella viridula) and western wheatgrass (Pascopyrum smithii). Thickspike wheatgrass (Elymus lanceolatus) becomes more common in the northern extent of MLRA 52. Other needlegrass (Hesperostipa) species show a similar pattern with shortbristle needle and thread, also known as western porcupine grass (Hesperostipa curtiseta), becoming more common north of the Milk River. The principal shrub on this site is silver sagebrush (Artemisia cana), which can be quite abundant in some areas.

Associated sites

FX052X01X032	**Loamy (Lo) Dry Grassland** The Loamy site is on slopes of less than 15 percent on moraines and till plains upslope from and commonly surrounding the Swale site.
FX052X01X040	**Loamy-Steep (Lostp) Dry Grassland** The Loamy Steep site is found on slopes of 15 percent or greater on hillslopes. The Swale site is found on concave slope positions where surface runoff is concentrated.
FX052X01X001	**Clayey (Cy) Dry Grassland** The Clayey site is on slopes of less than 15 percent on moraines and till plains upslope from and commonly surrounding the Swale ecological site. Soil horizon material contains greater than 35 percent clay.

Similar sites

FX052X03X062	**Swale (Se) Dry Shrubland** This site differs from Swale Dry Grassland in that it has slightly warmer annual temperatures and can support big sagebrush.
FX052X99X060	**Overflow (Ov)** This site differs from the Swale site in that it is on flood plains rather than upland swales. It generally is on stream terraces adjacent to a losing stream reach and in some areas has a water table greater than 40 inches below the soil surface.
FX052X01X032	**Loamy (Lo) Dry Grassland** This site differs from the Swale site in that it is in higher topographical positions that do not receive additional moisture whereas the Swale site is in the bottoms of coulees or swales and receives additional moisture.

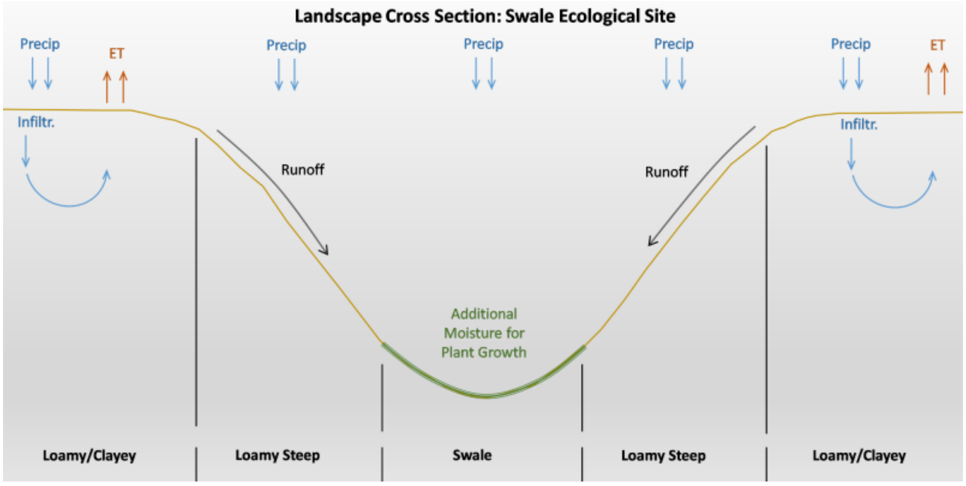

Figure 2. Figure 4. Diagram of associated sites and hydrologic patterns

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY062MT

Physiographic features

Swale Dry Grassland is a common ecological site on swale microfeatures on till plains, moraines, and outwash fans. This site is extensive across MLRA 52 but typically occurs as a minor component of most map units. It is typically in complex with Loamy or Clayey sites and is found on swale microfeatures that receive additional moisture via surface runoff from adjacent sites.

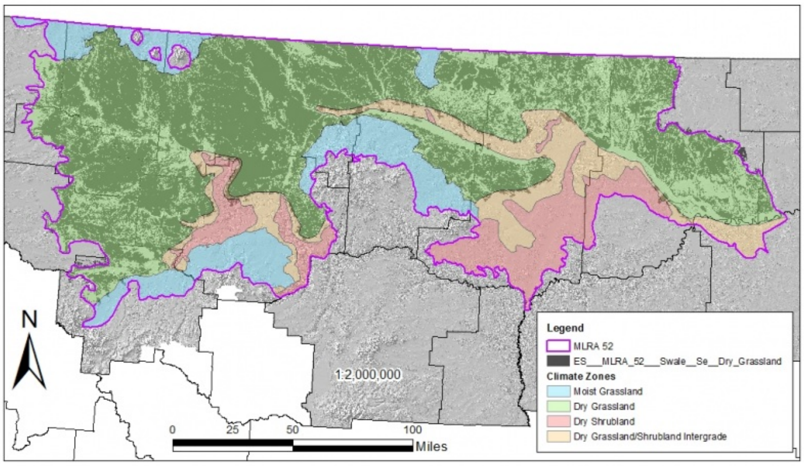

Figure 3. Figure 1. Map units containing Swale Dry Grassland ecological site as a minor component (<10% map unit composition)

Table 2. Representative physiographic features

Landforms	(1) Till plain > Moraine > Swale (2) Till plain > Fan > Swale
Elevation	2,000–3,870 ft
Slope	0–15%

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 is an 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 receives additional moisture from upslope sites via surface runoff. Moisture loss through evapotranspiration exceeds precipitation for the majority of the growing season, but this site receives enough moisture from runoff to remain moist much longer than adjacent sites. Typical precipitation events deliver enough moisture to fill the soil profile, but the site is not generally considered a recharge site. When seeded to annual crops, this site may become a discharge site, especially if adjacent cropland is in a wheat/fallow rotation. In this case the swale ecological site may be affected by saline seeps due to deep percolation from adjacent cropland.

Soil features

The central concept for this ecological site is best represented by Ferd, Acel, Ethridge, Evanston, and Kremlin soils occurring on swale microfeatures. The estimated extent of this ecological site in MLRA 52 is 300,000 acres. The Ferd and Acel soils are in the Haplustalfs great group and are characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon and an underlying argillic horizon where clay has accumulated through weathering. The Ethridge and Evanston soils are in the Argiustolls great group and have a relatively dark mollic epipedon and an underlying argillic horizon. The Kremlin soil is in the Haplustolls great group and has a mollic epipedon but lacks an argillic horizon. The particle-size family for these soils is fine-loamy or fine, and minerology is either smectitic or mixed. Local alluvium or glaciofluvial deposits are the typical parent materials for these series. 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 commonly loam and clay loam but can range from fine sandy loam to silty clay loam and typically contain between 20 to 35 percent clay. The underlying horizons typically contain 35 to 50 percent clay and have clay, clay loam, or silty clay loam textures. Organic matter content in the surface horizon typically ranges from 1 to 3 percent, and moist colors vary from grayish brown (10YR 5/2) to very dark grayish brown (10YR 3/2). The surface horizon of these soils does not typically react with hydrochloric acid. Depth to secondary carbonates is typically 15 inches or more below the soil surface. Calcium carbonate equivalent is typically less than 5 percent in the upper 5 inches and 10 percent or less in lower horizons. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. 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 is typically very deep (greater than 60 inches to bedrock). Content of coarse fragments is less than 35 percent in the upper 20 inches of soil and is typically less than 15 percent.

Table 4. Representative soil features

Parent material	(1) Alluvium (2) Glaciofluvial deposits
Surface texture	(1) Loam (2) Clay loam (3) Fine sandy loam (4) Silty clay loam
Drainage class	Well drained
Soil depth	60–72 in
Available water capacity (0-40in)	6.4–8 in
Calcium carbonate equivalent (0-5in)	0–4%
Electrical conductivity (0-20in)	0–3 mmhos/cm
Sodium adsorption ratio (0-20in)	0–12
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 Swale provisional ecological site in MLRA 52 Dry Grassland consists of four states: The Reference State (1.0), the Invaded 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 (Antilocarpa 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). 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, provide 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 cool-season midgrasses (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. Western wheatgrass appears to be relatively resistant to grazing on this site, presumably due to the increased moisture availability and the rhizomatous nature of the grass. Periods of drought can also reduce mid-statured cool-season grasses (Coupland, 1958, 1961). The warm-season species blue grama does not appear to be prevalent on this site; however, needleleaf sedge (*Carex duriuscula*) can be common and appears to increase under grazing pressure (Adams et al., 2013). Further degradation of the site due to improper grazing can result in reduced vigor of rhizomatous wheatgrasses and an increase in unpalatable forbs such as white sagebrush, more commonly known as cudweed sagewort (*Artemisia ludoviciana*). The cover of mid-statured bunchgrasses and sedges is severely reduced or absent. This site is quite resilient and has not been documented to cross a threshold into an altered state; however, in this condition the site is highly susceptible to invasion by non-native species. Introduced bluegrasses (Poa spp.) are the most common invasive species.

Due to the productivity of the soils, this ecological site has the potential to be productive cropland. However, conversion to cropland depends on the steepness of the site. Side slopes greater than 8 percent are generally inaccessible to farm equipment. Regardless, many acres have been cultivated and planted to cereal grain crops, such as winter wheat, spring wheat, and barley. Due to the concentration of runoff, this site is very susceptible to erosion when farmed and soil loss is common. Unfarmed swales are also susceptible to deposition when surrounding areas are farmed, and deposition impairs the ecological function of the site. When taken out of production, this site is most commonly seeded back to perennial grass. Introduced species such as pubescent wheatgrass are most common, but native species may also be seeded. Reseeding projects commonly involve extensive earthmoving and soil disturbance, therefore the site is unlikely to return to the Reference State even if seeded to native species. Sites seeded with non-native species may persist as this cover type indefinitely. Sites left to undergo natural plant succession after cultivation will most likely continue to erode and, as a result, have drastically altered soil properties, hydrology, and vegetation. Such a site may stabilize over time and support perennial vegetation, but is it likely that non-native or invasive species will be common. Under ideal circumstances, it may take over 75 years for soil organic matter to return to its pre-disturbed state (Dormaar et al., 1990); it is likely to take much longer in a swale if soil erosion is significant.

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 three 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 bunchgrasses, mid-statured cool-season rhizomatous grasses, and silver sagebrush. Dense spike-moss, also known as dense clubmoss (*Selaginella densa*), is commonly present and may constitute significant ground cover; however, it is absent in some areas. Its dynamics are not well understood, and its abundance appears to vary greatly from site to site without discernable reason.

Community Phase 1.1: Green Needlegrass – Rhizomatous Wheatgrass Phase
The Green Needlegrass – Rhizomatous Wheatgrass Phase is dominated by mid-statured cool-season bunchgrasses. Green needlegrass is the primary species although needle and thread is commonly present at low to moderate cover. Western porcupine grass also occurs and is most prevalent north of the Milk River. The mid-statured cool-season rhizomatous grasses are subdominant in this phase. Both western and thickspike wheatgrass may be present, with thickspike becoming more common in the northern extent of this site. Short-statured graminoids, such as blue grama and needleleaf sedge, are not abundant in this phase but are generally present at low cover. Common forbs are American vetch (*Vicia americana*), large Indian breadroot (*Pediomelum esculentum*), and common yarrow (*Achillea millefolium*). Silver sagebrush is the most common shrub and may comprise up to 10 percent of the canopy cover. Snowberry (Symphoricarpos spp.) is sometimes present at low cover. The approximate species composition of the reference plant community is as follows:

Percent composition by weight
Green Needlegrass 35%
Rhizomatous Wheatgrass 25%
Western Porcupine Grass 0-10%
Needle and Thread 5-10%
Other Native Grasses 5%
Perennial Forbs 15%
Shrubs/Subshrubs 5-10%

Estimated Total Annual Production (lbs/ac)*
Low - 900
Representative Value - 1250
High - 1600
*Estimated based on current data – subject to revision

Community Phase 1.2: Rhizomatous Wheatgrass - Needlegrass Phase
In the Rhizomatous Wheatgrass – Needlegrass Phase, mid-statured rhizomatous wheatgrasses have replaced green needlegrass as the dominant plant species. Green needlegrass has been significantly reduced and persists at low cover, typically less than 5 percent of species composition. The mid-statured bunchgrasses are dominated by other needlegrass species, such as needle and thread or western porcupine grass. Needleleaf sedge may also increase in this phase. Unpalatable forbs, such as cudweed sagewort and common yarrow, also increase in abundance. The species structure has begun to shift from dominantly bunchgrasses to dominantly rhizomatous grasses.

Community Phase 1.3: At-Risk Phase

Prolonged drought (approximately 3 years or more) or continued improper grazing may transition the Rhizomatous Wheatgrass – Needlegrass Phase to the At-Risk Phase. In the At-Risk Phase, mid-statured bunchgrasses have been eliminated or nearly so. The plant community is dominated by rhizomatous wheatgrasses, primarily western wheatgrass, but vigor is reduced and unpalatable forbs are common. Cover of blue grama increases, but information suggests that blue grama tends not to dominate this site as it does other sites. The decreased vigor of native species may make this phase more susceptible to invasion by non-native species such as Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*Poa compressa*).

Community Phase Pathway 1.1a
Drought, improper grazing management, or a combination of these factors can shift the Green Needlegrass – Rhizomatous Wheatgrass Phase (1.1) to the Rhizomatous Wheatgrass - Needlegrass Phase (1.2). These factors favor a decrease in cool-season midgrasses (Coupland, 1961).

Community Phase Pathway 1.2a
The Rhizomatous Wheatgrass - Needlegrass Phase can return to the Green Needlegrass – Rhizomatous Wheatgrass Phase (1.1) with normal or above-normal spring precipitation and proper grazing management.

Community Phase Pathway 1.2b
Prolonged drought, continued improper grazing practices, or a combination of these factors can shift the Rhizomatous Wheatgrass - Needlegrass Phase to the At-Risk Phase. The Rhizomatous Wheatgrass - Needlegrass Phase transitions to the At-Risk Phase when mid-statured bunchgrasses become rare and contribute little to production. In addition, mid-statured rhizomatous grass cover is reduced and vigor is lowered.

Community Phase Pathway 1.3a
The At-Risk Phase (1.3) can return to the Rhizomatous Wheatgrass - Needlegrass Phase (1.2) with normal or above-normal spring precipitation and proper grazing management.

Transition T1A
The Reference State (1) transitions to the Invaded State (2) when aggressive perennial grasses or noxious weeds invade. Kentucky bluegrass is a widespread invasive species in the northern Great Plains (Toledo et al., 2014). Decreased vigor of native species may be one factor that increases susceptibility to grazing. Studies have also shown that exclusion of grazing and fire favors invasive bluegrass species (Dekayser et al., 2013).

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: Invaded State
The Invaded State (2) occurs when invasive plant species invade adjacent native grassland communities. Introduced bluegrasses such as Kentucky and Canada bluegrass are the most common concerns. Kentucky bluegrass, in particular, is widespread throughout the Northern Great Plains (Toledo et al., 2014). It is very competitive and displaces native species by forming dense root mats, altering nitrogen cycling, and creating allelopathic effects on germination (DeKeyser et al., 2013). Plant communities dominated by Kentucky bluegrass have significantly less cover of native grass and forb species (Toledo et al., 2014; Dekeyser et al., 2009). Kentucky bluegrass can persist in either grazed or non-grazed sites and can substantially increase under long-term grazing exclusion (DeKeyser et al., 2009; Grant et al., 2009). Effects on soil quality are still unknown at this time, but possible concerns are alteration of surface hydrology and modification of soil surface structure (Toledo et al., 2014). Reduced plant species diversity, simplified structural complexity, and altered biologic processes result in a state that is substantially departed from the Reference State (1).

Noxious weeds are not widespread in MLRA 52, but leafy spurge and Canada thistle have both been documented on this site. These species are very aggressive perennials. They typically displace native species and dominate ecological function when they invade a site. In some cases, these species can 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 and structural complexity 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 T2A
Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Invaded State (2) to the Cropland State (3).

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. The Swale ecological site is highly susceptible to erosion due to the lack of perennial species in this state. Wheat/fallow rotations are also very inefficient at removing moisture from the soil in comparison to native vegetation. In some cases, the Swale ecological site may receive ground-water discharge from surrounding sites. In areas where soils or underlying parent materials have a high amount of soluble salts, a saline seep may develop.

Transition T3A
The transition from the Cropland State (3) to the Post-Cropland State (4) occurs with the cessation of cultivation. The site may also be seeded to perennial forage species, such as pubescent wheatgrass and alfalfa, or a mix of native species. This transition frequently involves extensive earthmoving, grading, and shaping of the site.

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 is susceptible to erosion that is likely to result in downcutting and gullying. Eventually, the site will probably stabilize and re-vegetate to a perennial grassland community, but not before a significant amount of soil has been lost. Due to significant changes in soil structure, organic matter content, and, possibly, hydrology, the site is unlikely to return to the Reference State. Invasion of the site by exotic species, such as Kentucky bluegrass, and annual bromes will depend upon the site’s proximity to a seed source.

Phase 4.2: Perennial Grass Phase
When the site is seeded to perennial forage species, particularly introduced perennial grasses, this community phase can persist for several decades. Smooth brome (*Bromus inermis*), in particular, is very aggressive. It frequently forms a monoculture and can invade adjacent sites if conditions are favorable. Typically, extensive earthmoving is employed to grade and shape the site prior to seeding. In most cases, the site is seeded to introduced rhizomatous grasses, such as pubescent wheatgrass, to control erosion. 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, soil properties have been substantially altered and are unlikely return to pre-cultivation conditions within a reasonable timeframe. After reseeding, the surrounding area commonly remains in cropland and the Swale ecological site is managed as a grassed waterway. Under these conditions, the site is subject to deposition from surrounding slopes and requires continual management to prevent sedimentation.

Transition 5A
The Post-Cropland State (4) transitions back to the Cropland State (3) when the site is converted to cropland.

State and transition model

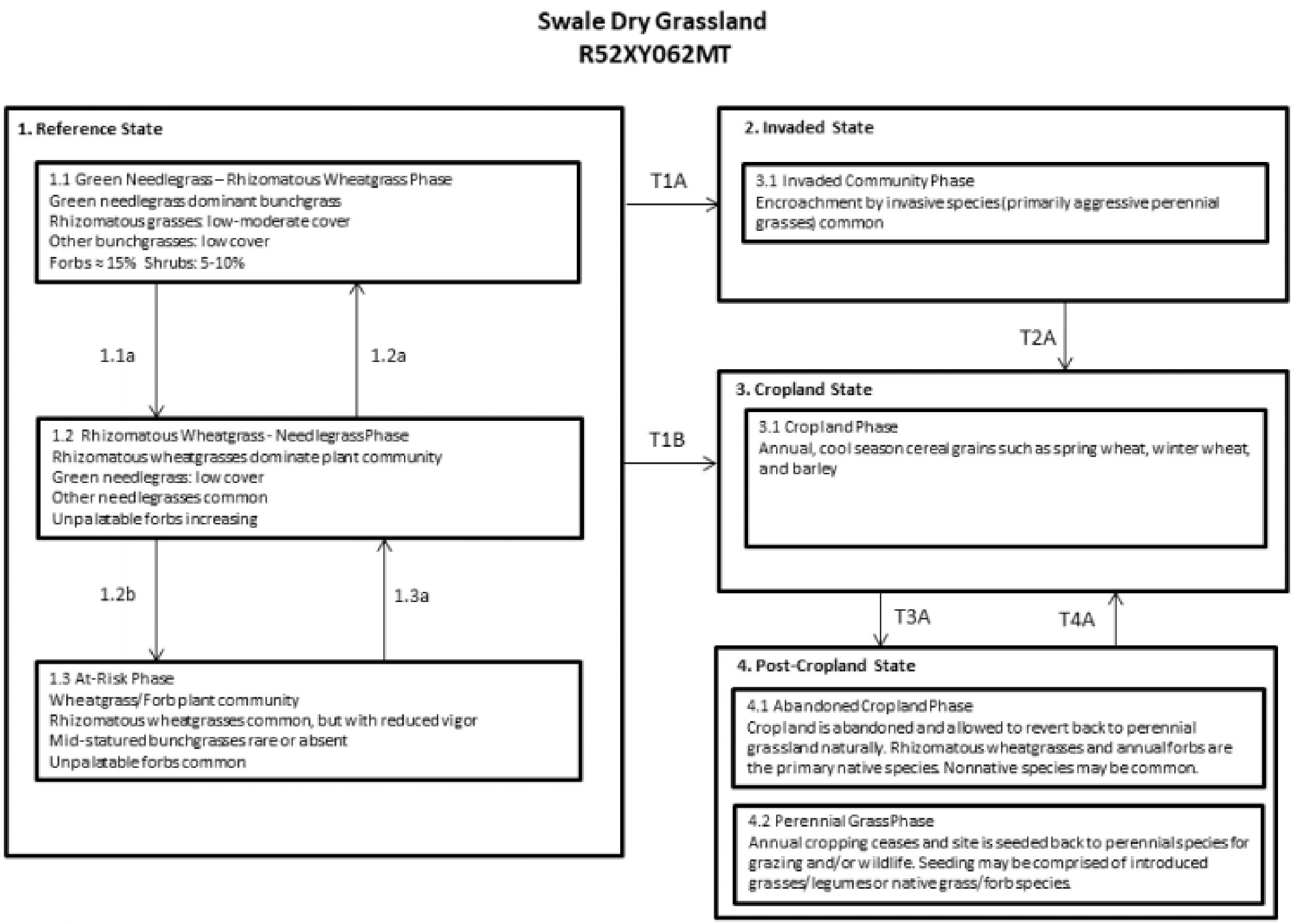

Figure 2: State-and-transition diagram

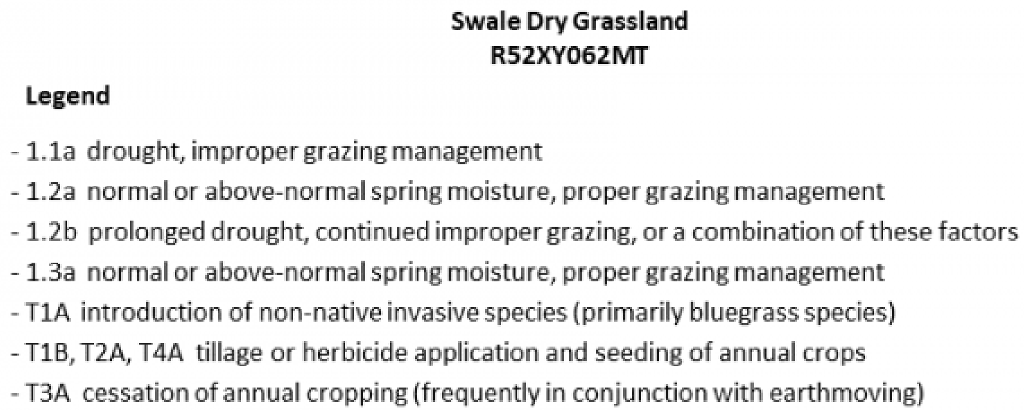

Figure 3: State and Transition Diagram

Inventory data references

Data for this provisional ecological site was obtained from a total of 3 plots of low to medium intensity. The Reference State (1) was represented by one medium-intensity plot and the Invaded State (2) by two-low intensity plots. No quantitative data were obtained for other community phases. 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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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:**