Ecological site FX052X99X071
Recharge Closed Depression (Cdr)

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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.

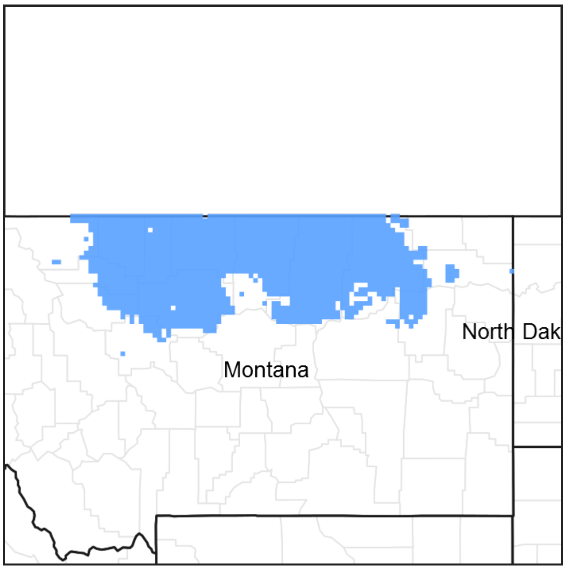

Figure 1. Mapped extent

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

Soils are primarily Mollisols, 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). It 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 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 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: N/A

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: Shrub and Herb Wetland Subclass (2.C)
• Formation: Temperate to Polar Freshwater Marsh, Wet Meadow, and Shrubland Formation (2.C.4)
• Division: Salix interior / Juncus spp. - Eupatorium perfoliatum Wet Meadow and Shrubland Division (2.C.4.Nd)
• Macrogroup: Spartina pectinata - Typha spp. - Schoenoplectus spp. Great Plains Marsh, Wet Meadow, Shrubland, and Playa Macrogroup (2.C.4.Nd.5)
• Group: Spartina pectinata - Calamagrostis stricta - Carex spp. Great Plains Wet Prairie, Wet Meadow, and

Seepage Fen Group (2.C.4.Nd.5.b)
• Alliance: No existing correlation
• Association: No existing correlation

USFWS (Cowardin et al., 1979)
• Palustrine Emergent Temporarily Flooded and Palustrine Emergent Seasonally Flooded

Classification of natural ponds and lakes in the Glaciated Prairie Region (Stewart and Kantrud, 1971)
• Ephemeral Pond, Temporary Pond, and Seasonal Pond

Ecological site concept

This provisional ecological site occurs in all climatic zones of MLRA 52. Figure 1 illustrates the distribution of closed depression ecological sites based on current data. Current mapping does not differentiate between recharge and discharge ecological sites, therefore this map will require future revision. Recharge Closed Depression is an extensive ecological site occurring throughout MLRA 52 in depressions on moraines and till plains. The ponding duration is typically temporary or seasonal; however, it is highly variable depending on catchment size and annual precipitation. This site is typically nonsaline.

The distinguishing characteristics of this site are that it is located in closed depression landforms, receives surface runoff from adjacent uplands, and contains hydric soils. Soils for this ecological site are typically very deep (more than 60 inches) and derived from alluvium. Soil textures in the upper 4 inches are typically silt loam, clay loam, or clay. Soils typically have slow permeability rates, which cause ponding following runoff events (USDA-NRCS, 2016). Characteristic vegetation is western wheatgrass (Pascopyrum smithii), needleleaf sedge (Carex duriuscula), and spikerush (Eleocharis spp.).

Associated sites

FX052X01X062	**Swale (Se) Dry Grassland** The Swale ecological site is in upland coulees and swales. It is typically upslope from the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X03X062	**Swale (Se) Dry Shrubland** The Swale ecological site is in upland coulees and swales. It is typically upslope from the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X02X062	**Swale (Se) Moist Grassland** The Swale ecological site is in upland coulees and swales. It is typically upslope from the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X02X032	**Loamy (Lo) Moist Grassland** The Loamy ecological site is in uplands surrounding the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X01X032	**Loamy (Lo) Dry Grassland** The Loamy ecological site is in uplands surrounding the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X03X032	**Loamy (Lo) Dry Shrubland** The Loamy ecological site is in uplands surrounding the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X02X040	**Loamy-Steep (Lostp) Moist Grassland** The Loamy Steep ecological site is on slopes greater than 15 percent surrounding the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X01X040	**Loamy-Steep (Lostp) Dry Grassland** The Loamy Steep ecological site is on slopes greater than 15 percent surrounding the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.

FX052X03X040	**Loamy-Steep (Lostp) Dry Shrubland** The Loamy Steep ecological site is on slopes greater than 15 percent surrounding the Recharge Closed Depression ecological site on till plains and moraines. It contributes surface water to the Recharge Closed Depression ecological site.
FX052X99X705	**Discharge Closed Depression (Cdr)** The Discharge Closed Depression ecological site is on landforms similar to those of the Recharge Closed Depression ecological site. It typically is in lower topographic positions and receives ground-water discharge from the Recharge Closed Depression ecological site.

Similar sites

FX052X99X084	**Slough (Sl)** The Slough ecological site is on flood plains, commonly in oxbows or channels where flooding is very frequent and a water table is shallow and persistant. Its hydroperiod is typically much longer than that of the Recharge Closed Depression ecological site. This site typically contains deep marsh vegetation.
FX052X99X060	**Overflow (Ov)** The Overflow ecological site occurs on flood plains, commonly on higher terraces that receive additional moisture from runoff and stream overflow. Vegetation is dominated by facultative upland species.
FX052X99X705	**Discharge Closed Depression (Cdr)** The Discharge Closed Depression ecological site differs from the Recharge Closed Depression ecological site in that it receives a significant amount of moisture from ground-water discharge as well as surface runoff. Water and soils are typically more saline, and salt-tolerant vegetation is common.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Legacy ID

R052XY071MT

Physiographic features

Recharge Closed Depression is an extensive ecological site occurring in depressions on moraines and till plains

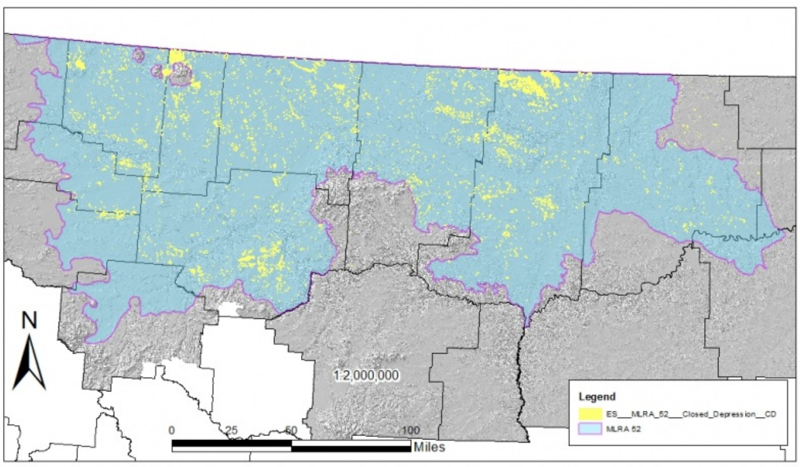

Figure 2. Figure 1. General distribution of Closed Depression ecological sites by mapunit extent

Table 2. Representative physiographic features

Landforms	(1) Till plain > Depression (2) Till plain > Moraine > Closed depression
Ponding duration	Brief (2 to 7 days) to long (7 to 30 days)
Ponding frequency	Occasional to frequent
Elevation	2,000–4,600 ft
Slope	0–2%
Ponding depth	0–12 in
Water table depth	0–60 in
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 115 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 every 10 years. Annual precipitation ranges from 10 to 17 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)	115 days
Freeze-free period (average)	140 days
Precipitation total (average)	13 in

Climate stations used

- (1) GERALDINE [USC00243445], Geraldine, MT
- (2) CONRAD [USC00241974], Conrad, MT
- (3) TURNER 11N [USC00248415], Turner, MT
- (4) CONTENT 3 SSE [USC00241984], Zortman, MT
- (5) GOLDBUTTE 7 N [USC00243617], Sunburst, MT
- (6) SACO 1 NNW [USC00247265], Saco, MT
- (7) CARTER 14 W [USC00241525], Floweree, MT
- (8) CHESTER [USC00241692], Chester, MT
- (9) HARLEM [USC00243929], Harlem, MT
- (10) LOMA 1 WNW [USC00245153], Loma, MT

Influencing water features

This is a depressional wetland site that receives additional moisture via surface runoff. Hydrology is most similar to a recharge depressional hydrogeomorphic (HGM) model, although water rarely reaches a ground-water table because evapotranspiration greatly exceeds precipitation. Runoff from surrounding uplands enters the site and is unable to infiltrate rapidly due to the high clay content of the soils. Water ponds on the surface for a brief time, then is lost by evapotranspiration. The ponding duration is typically 4 weeks or less, but some areas may pond water for 3 to 4 months. In the latter case, there may be some subsurface flow of water into lower landscape positions or ground water. Ponding depth is typically 1 foot or less.

Soil features

The Recharge Closed Depression concept covers over 160,000 acres in MLRA 52. Soils that best represent the central concept for this ecological site are Nishon and Dimmick. The Nishon soil is in the Albaqualfs great group while the Dimmick soil is in the Epiaquolls great group. The Nishon soil is characterized by a surface horizon that lacks enough organic matter to have a mollic epipedon while the Dimmick soil has a mollic epipedon. Both soils are in the fine family, meaning they contain between 35 and 60 percent clay in the particle-size control section, and have smectitic mineralogy. Parent material for these series is clayey alluvial deposits. These and all other soils in this site concept typically receive moisture from surface runoff but in some instances can receive additional moisture from nearby depressions when they are in close proximity to one another. Ponding frequency varies from occasional to frequent. Duration varies from brief to long, depending on catchment size and annual precipitation. All soils in this concept have an aquic moisture regime, which means that the soils are saturated within 40 inches (100 cm) of the mineral soil surface for some time during the year. These soils have a frigid soil temperature regime (Soil Survey Staff, 2014).

Soil textures in the surface horizon on this site are typically loam, silt loam, clay loam, or clay; the underlying horizons are typically clay. Hydric features, such as redox, or gleying may be present in any horizon. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. The surface horizon typically contains 3 to 6 percent organic matter; and moist colors vary from gray (10YR 5/1) to very dark gray (10YR 3/1). Calcium carbonate equivalent is typically less than 5 percent in the upper 5 inches of soil. Soil pH classes are slightly acid to neutral in the surface horizon and neutral to strongly alkaline in the subsurface horizons. The soil depth class for this is site is typically very deep (more than 60 inches). Typically, the upper 20 inches of soil does not contain coarse fragments.

Table 4. Representative soil features

Parent material	(1) Alluvium
Surface texture	(1) Loam (2) Silt loam (3) Clay loam (4) Clay
Drainage class	Poorly drained to very poorly drained
Soil depth	60–72 in
Available water capacity (0-40in)	6.3–7.1 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)	6.1–9

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 Recharge Closed Depression provisional ecological site in MLRA 52 Dry Grassland consists of five vegetative states: The Reference State (1), the Invaded State (2), the Undrained Cropland State (3), the Impounded State (4) and the Drained Cropland State (5). Historically, plant communities associated with the Recharge Closed Depression ecological site evolved under the combined influences of climate, grazing, hydrology, and fire. Extreme climatic variability results in frequent droughts, which can have great influence on the relative contribution of species cover and production (Coupland, 1958, 1961; Biondini et al., 1998).

Hydrology is a crucial dynamic on this site. The site receives water from surface runoff primarily from spring snowmelt and from high-intensity thunderstorms. The duration of ponding, or hydroperiod, dramatically influences the vegetation of the site. The hydroperiod varies depending on catchment size and annual precipitation patterns. The majority of sites in MLRA 52 contain water for only a few weeks in the spring. Larger catchment basins, above-average precipitation cycles, or a combination of these factors may increase the hydroperiod to several months. Plant communities vary depending on the hydroperiod.

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

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 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, fires were less frequent on the Recharge Closed Depression ecological site than on adjacent drier sites; however, early reports indicate that fires did occur in wetlands (Higgins, 1986). The Recharge Closed Depression ecological site is resilient to fire, and the historic fire return interval most likely had very little effect on the plant community (except for removing excess litter accumulations). However, long-term fire suppression in the 20th century removed periodic fire from the ecosystem altogether. This practice lead to an increase in litter accumulation, which in some cases, may provide ideal conditions for seed germination and seedling establishment of invasive species, such as Canada thistle (*Cirsium arvense*).

Plant communities on the Recharge Closed Depression ecological site are very complex. Much of the dynamics of this site are still under investigation and are not fully understood. Sites commonly contain multiple plant community zones that correspond to the hydroperiod for that portion of the site. In the Ephemeral Phase (1.1), the hydroperiod is only 7 to 10 days early in the spring and the site supports facultative upland species. The center of the depression is dominated by a wheatgrass plant community that transitions to a wheatgrass-sedge community toward the rim. Periods of above-average precipitation or depressions with a moderate catchment size will transition to the Temporarily Ponded Phase (1.2). In this phase, the hydroperiod increases to 1.5 to 4 weeks and the site begins to support more hydrophytic wetland vegetation. There are typically two distinct vegetation zones with a wheatgrass-spikerush plant community occupying the center of the depression. The rim of the depression transitions to wheatgrass or a wheatgrass-sedge plant community. The Seasonally Ponded Phase (1.3) occurs primarily in depressions that have large catchment basins, although it can occur in moderate-sized catchment basins during periods of above-average precipitation. The hydroperiod for this phase is much longer, typically 1 to 4 months, and is sufficient for the establishment of a significant amount of hydrophytic vegetation. The center of the depression commonly supports a spikerush-dominated plant community, which is surrounded by a wheatgrass-spikerush plant community, and the rim supports wheatgrass or wheatgrass-sedge species. Plant communities in all phases are often dynamic, and diversity varies from site to site. Further study is needed to fully describe all major species and plant community dynamics.

Disturbances to the Recharge Closed Depression ecological site can have significant effects on hydrology and vegetation. Disturbances that directly affect the site include, but are not limited to, excavation, draining, impoundment, conversion to cropland, and grazing. The effects of improper grazing on this site have not been documented in detail, but improper grazing is known to cause a reduction in palatable forage species and an increase in unpalatable species, such as white sagebrush (*Artemisia ludoviciana*), and mountain rush (*Juncus arcticus* ssp. littoralis), also known as or Baltic rush. 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.

The most common disturbance on this site is conversion to cropland. Smaller depressions, particularly those with ephemeral hydroperiods, are frequently farmed with no further alteration. Seasonally ponded depressions are typically too wet to farm without artificial drainage. Typically, water is drained by ditching and then the site is converted to cropland. In these cases, the natural hydrology is severely altered and the site is unlikely to return to the Reference State (1) without significant restoration. Another common alteration of hydrology is due to impoundment of water for livestock or wildlife. Impoundment increases the hydroperiod and effectively converts the site from a temporarily or seasonally ponded wetland to a semi-permanent wetland.

Invasive species are a common concern on this ecological site. Non-native perennial grasses, such as Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*), are widespread throughout the Great Plains (Toledo et al., 2014). Sites that are in the Ephemeral Phase (1.1) or the Temporarily Ponded Phase (1.2) are particularly prone to invasion by these species. Wetter, seasonally ponded sites appear to have fewer non-native species but may still be affected by more ponding-tolerant species, such as reed canarygrass (*Phalaris arundinacea*) and creeping meadow foxtail (*Alopecurus arundinaceus*). Noxious weeds, such Canada thistle and leafy spurge (*Euphorbia esula* L.), have also been documented on this site.

The state-and-transition (STM) diagram (Figure 2) suggests possible pathways that plant communities on this site may follow as a result of a given set of ecological processes and management. The site may also support vegetative 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 State (1) may not necessarily be the management goal. The lists of plant species and species composition values are provisional and are not intended to cover the full range of conditions, species, and responses for the site. Species composition by dry weight is provided when available and is considered provisional based on the sources identified in the narratives associated with each community phase.

State 1: Reference State
The Reference State (1) contains three community phases. Ecological dynamics of this state are still under investigation, therefore, this model may not cover the full range of conditions, species, and responses for the state. Seasonal ponding is a key dynamic on this site and varies depending on annual precipitation patterns and catchment size. Vegetation is characterized by concentric rings, or zones, within the depression that correspond to the hydroperiod of that particular zone. The Ephemeral Phase (1.1) may only exhibit one vegetation zone dominated by facultative upland species. Other phases may exhibit two or more zones where the most hydrophytic vegetation is in the center of the depression and subsequent, drier plant communities are toward the edges. Diagnostic plant associations that occur on the Recharge Closed Depression ecological site are western wheatgrass, western wheatgrass-needleleaf sedge, western wheatgrass-needle spikerush, and common spikerush (Crowe and Kudray, 2003). Plant communities can be diverse and may contain numerous other species in addition to the diagnostic species. Table 5 contains a list of species that have been observed in the Reference State (1).

Community Phase 1.1: Ephemeral Phase
The Ephemeral Phase (1.1) occurs in depressions with small catchment areas but can also occur in depressions with moderate-sized catchment areas during drought years. The hydroperiod in this phase is very short, typically 10 days or less. The western wheatgrass community frequently is the only one present, although a wheatgrass-needleleaf sedge association may occur along the depression rim.

Community Phase Pathway 1.1a
In small catchment areas, 2 to 3 years of above-average precipitation will transition the Ephemeral Phase (1.1) to the Temporarily Ponded Phase (1.2). Moderate-sized catchment areas will transition to this phase during average-precipitation years.

Community Phase 1.2: Temporarily Ponded Phase
The Temporarily Ponded Phase (1.2) occurs in depressions with moderate-sized catchment areas during normal years, but it may also occur in small catchment areas during wet cycles or in large catchment areas during drought. In this phase the hydroperiod ranges from 1.5 to 4 weeks. Vegetation begins to exhibit zonation in this phase. At the center of the depression, ponding is longest and a wheatgrass-spikerush plant community appears. The most common species in this zone are western wheatgrass and needle spikerush, although common spikerush may also

be present. A wheatgrass-needleleaf sedge community is commonly present around the rim of the depression. A number of minor graminoid species, such as American sloughgrass (*Beckmannia syzigachne*) and rough bentgrass (*Agrostis scabra*), may also be present.

Community Phase Pathway 1.2a
In moderate-sized catchment areas, drought will transition the Temporarily Ponded Phase (1.2) to the Ephemeral Phase (1.1). Small catchment areas will transition to this phase during average-precipitation years.

Community Phase Pathway 1.2b
In moderate-sized catchment areas, 2 to 3 years of above-average precipitation will transition the Temporarily Ponded Phase (1.2) to the Seasonally Ponded Phase (1.3).

Community Phase 1.3: Seasonally Ponded Phase
The Seasonally Ponded Phase (1.3) occurs in depressions with large catchment areas, although it can occur in moderate-sized catchment areas during wet cycles. The hydroperiod in this phase is 1 to 4 months, and the vegetation typically exhibits three or more zones. The wettest zone in this phase is typically a spikerush-dominated community. This transitions into a middle zone with a wheatgrass-spikerush community. The rim of the depression in this phase is typically a wheatgrass-needleleaf sedge association, although a western wheatgrass-dominated community may be present in some cases. A number of minor species, such as sedges, rushes, and smartweed, may also be present.

Community Phase Pathway 1.3a
In large catchment areas, drought will transition the Seasonally Ponded Phase (1.3) to the Temporarily Ponded Phase (1.2). Moderate-sized catchment areas will transition to this phase during average precipitation years.

Transition T1A
Tillage or application of herbicide and seeding of cultivated crops (such as wheat, barley, or introduced hay) transitions the Reference State (1) to the Undrained Cropland State (3). This transition occurs primarily in the Ephemeral Phase (1.1) or the Temporarily Ponded Phase (1.2).

Transition T1B
Artificial impoundment of water by damming or excavation transitions the Reference State (1) to the Impounded State (4).

Transition T1C
Introduction of invasive species, particularly Kentucky bluegrass and smooth brome, transitions the Reference State (1) to the Invaded State (2).

Transition T1D
The combination of artificial drainage, tillage or herbicide application, and seeding of annual crops transitions the Reference State (1) to the Drained Cropland State (4). This transition occurs primarily on the Seasonally Ponded Phase (1.3).

State 2: Invaded State
The Invaded State (2) occurs when invasive plant species invade adjacent native plant communities. Introduced perennial grasses, such as Kentucky bluegrass and smooth brome, are the most common concerns. These species are widespread throughout the northern Great Plains (Toledo et al., 2014). They are very competitive and displace native species by forming dense root mats, altering nitrogen cycling, and having allelopathic effects on germination (DeKeyser et al., 2013). Plant communities dominated by Kentucky bluegrass and smooth brome have significantly less cover of native grass and forb species (Toledo et al., 2014; Dekeyser et al., 2009). Effects on soil quality and hydrology are still unknown at the time of this writing, 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 vegetative state that is substantially departed from the Reference State (1).

Noxious weeds are not widespread on the Recharge Closed Depression ecological site; however, leafy spurge and Canada thistle have both been documented as a concern on this site (Cooper and Jones, 2003: Crowe and Kudray, 2003; Jones, 2004). These species are very aggressive perennials that typically displace native species and dominate ecological function when they invade a site. 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 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.

Community Phase 2.1: Invaded Community Phase
The Invaded Community Phase (2.1) occurs when non-native perennial grasses or noxious weeds invade the site. In the Ephemeral Phase (1.1) or the Temporarily Ponded Phase (1.2), Kentucky bluegrass and smooth brome are the primary invasive species. Noxious weeds such as Canada thistle may also be a concern in some areas. Because invasive species have not been well documented in the Seasonally Ponded Phase (1.3), conclusive determinations are not available. Possible invasive species in these phases are reed canarygrass and creeping meadow foxtail, but this observation is considered hypothetical until further investigation.

Transition T2A
Tillage or herbicide application and seeding of cultivated crops (wheat, barley, or introduced hay) transitions the Invaded State (2) to the Undrained Cropland State (3). This transition occurs primarily in the Ephemeral Phase (1.1) or the Temporarily Ponded Phase (1.2).

Transition T2B
Artificial impoundment of water by damming or excavation transitions the Reference State (1) to the Impounded State (4).

State 3: Undrained Cropland State
The Undrained Cropland State (3) occurs when native vegetation is killed out, either by tillage or by herbicide application, and the site is seeded to annual crops. No other alterations are made to the natural hydrology or soils. This state typically only occurs in the Ephemeral Phase (1.1) or the Temporarily Ponded Phase (1.2). In this state the site is suitable for spring-seeded crops such as spring wheat and barley, although seeding of crops may be delayed 2 to 3 weeks due to wet soil conditions. In wet years, this state may be too wet to farm and will transition to the Wet/Foxtail Barley Phase (3.2).

Community Phase 3.1: Annual Crops Phase
The Annual Crops Phase (3.1) occurs when land is put into cultivation. Major crops include spring wheat, barley, and peas.

Community Phase Pathway 3.1a
One or more years of above-average precipitation transitions the Annual Crops Phase (3.1) to the Wet/Foxtail Barley Phase (3.2)

Community Phase 3.2: Wet/Foxtail Barley Phase
The Wet/Foxtail Barley Phase (3.2) occurs when precipitation is above average and the site is too wet to seed crop. Foxtail barley and annual weeds such as Kochia (*Bassia scoparia*) may colonize the site.

Community Phase Pathway 3.2a
Average or below-average precipitation transitions the Wet/Foxtail Barley Phase (3.2) to the Annual Crops Phase (3.1)

Transition T3A
Cessation of annual cropping combined with the introduction of invasive species transitions the site from the Undrained Cropland State (3) to the Invaded State (2). Non-native species, such as Kentucky bluegrass and smooth brome, are common.

Restoration Pathway R3A
Cessation of annual cropping combined with the reestablishment of native species transitions the site from the Undrained Cropland State (3) to the Reference State (1). Specialized seeding techniques may be necessary, depending on site conditions, as well as intensive weed control to prevent invasion of non-native species, such as Kentucky bluegrass and smooth brome. These restoration methods are labor intensive and costly and may not be practical in all situations.

State 4: Impounded State
The Impounded State (4) occurs when water is artificially impounded on the site by damming or excavation. Water may be impounded for livestock or wildlife. Impoundment of water typically transitions the site to a semi-permanent wetland with open water, deep marsh, and shallow marsh vegetation zones. In many cases impoundment creates a larger wetland with high-quality habitat for wildlife. In other cases, such as when an excavated pond is constructed in the center of the depression, a small semi-permanent wetland is created in the center while the remainder of the depression is drained, thus reducing total wetland area. In either case the natural hydrology of the site is significantly altered, resulting in a new state with different plant communities and ecological dynamics.

Community Phase 4.1: Cattail-Bulrush Phase
The Cattail-Bulrush Phase (4.1) occurs when water is impounded and the site is semi-permanently ponded. The hydroperiod in this phase is typically 6 to 9 months. Vegetation zonation has reached its maximum. Typically, the center of the site is open water, which is surrounded by a deep marsh zone dominated by broadleaf cattail (*Typha latifolia*), hardstem bulrush (*Schoenoplectus acutus*), and common threesquare (*Schoenoplectus pungens*). The rim of the depression is characterized by a shallow marsh zone supporting sedge and spikerush species. A wet meadow or low prairie zone of western wheatgrass or wheatgrass-spikerush may form at the outermost edges where ponding duration is shortest.

Restoration Pathway R4A
Restoration of natural hydrology and reestablishment of native species transition the site from the Impounded State (4) to the Reference State (1). Specialized seeding techniques may be necessary, depending on site conditions, as well as intensive weed control to prevent invasion of non-native grasses and noxious weeds. Restoration of natural hydrology may require removal of dams or refilling of excavated pits. These restoration methods are labor intensive and very costly and may be impractical, perhaps even detrimental, in some situations.

State 5: Drained Cropland State
The Drained Cropland State (5) occurs when the site is drained, tilled or sprayed, and seeded to annual crops. Surface water is typically drained by means of surface ditches, diversions, or both. Following drainage, remaining native vegetation is killed out either by tillage or herbicide application, then the site is seeded to annual crops. The hydrology of the site is significantly altered and no longer functions in its natural condition.

Community Phase 5.1: Drained Cropland Phase
The Drained Cropland Phase (5.1) occurs when the land is drained and put into cultivation. Major crops include spring wheat, winter wheat, and barley.

Restoration Pathway R5A
Cessation of annual cropping combined with the restoration of natural hydrology and the reestablishment of native species transitions the site from the Drained Cropland State (5) to the Reference State (1). Specialized seeding techniques may be necessary, depending on site conditions, as well as intensive weed control to prevent invasion of non-native grasses and noxious weeds. Restoration of natural hydrology may require removing diversions, plugging drainage ditches, or both. These restoration methods are labor intensive and very costly and may be impractical in some situations.

State and transition model

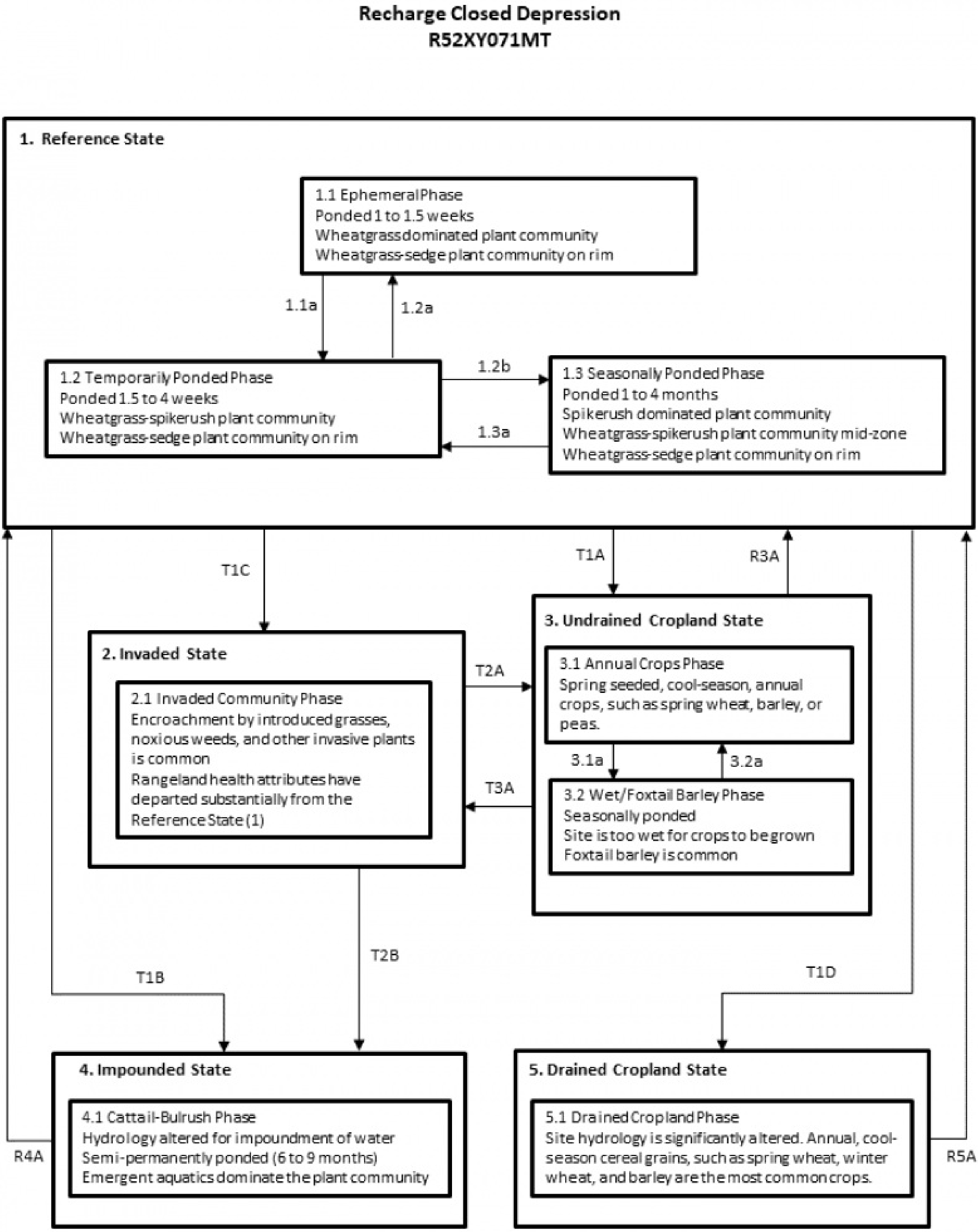

Figure 2. State-and-transition diagram

Recharge Closed Depression
R52XY071MT

Legend

- 1.1a 2 to 3 consecutive years of above average precipitation
- 1.2a drought
- 1.2b 2 to 3 consecutive years of above average precipitation: larger catchment area
- 1.3a drought
- T1A, T2A tillage or herbicide application and seeding of annual crops
- T1B, T2B artificial impoundment of water
- T1D artificial drainage, tillage or herbicide application, and seeding of annual crops
- T1C introduction of invasive species
- 3.1a 1 more years of above average precipitation
- 3.2a average or below average precipitation
- T3A cessation of annual cropping combined with introduction of invasive species
- R3A cessation of annual cropping combined with reestablishment of native species
- R4A, R5A restoration of natural hydrology and reestablishment of native species (labor intensive and costly)

Figure 3: State-and-transition legend

Table 5. List of plant species observed in temporally and seasonally flooded depressional wetlands (adapted from Jones [2004])

Scientific Name	Common Name	Growth Form	Duration
Achillea millefolium	common yarrow	Forb	Perennial
Agrostis scabra	rough bentgrass	Graminoid	Perennial
Argentina anserina	silverweed cinquefoil	Forb	Perennial
Arnica fulgens	foothill arnica	Forb	Perennial
Artemisia cana	silver sagebrush	Shrub	Perennial
Artemisia ludoviciana	white sagebrush	Forb	Perennial
Beckmannia syzigachne	American sloughgrass	Graminoid	Annual/Biennial
Bouteloua gracilis	blue grama	Graminoid	Perennial
Carex atherodes	wheat sedge	Graminoid	Perennial
Carex duriuscula	needleleaf sedge	Graminoid	Perennial
Carex pellita	woolly sedge	Graminoid	Perennial
Cerastium nutans	nodding chickweed	Forb	Annual/Biennial
Collomia linearis	tiny trumpet	Forb	Annual/Biennial
Cryptantha torreyana	Torrey's cryptantha	Forb	Annual/Biennial
Deschampsia caespitosa	tufted hairgrass	Graminoid	Perennial
Descurainia incana	mountain tansymustard	Forb	Annual/Biennial
Eleocharis acicularis	needle spikerush	Graminoid	Perennial
Eleocharis palustris	common spikerush	Graminoid	Perennial
Festuca spp.	fescue	Graminoid	Perennial
Glaux maritima	sea milkwort	Forb	Perennial
Gnaphalium palustre	western marsh cudweed	Forb	Annual/Biennial
Grindelia squarrosa	curlycup gumweed	Forb	Annual/Biennial
Juncus arcticus ssp. littoralis	Baltic rush	Graminoid	Perennial
Koeleria macrantha	prairie junegrass	Graminoid	Perennial
Lepidium densiflorum	common pepperweed	Forb	Annual/Biennial
Leptochloa fusca ssp. *fascicularis*	bearded sprangletop	Graminoid	Annual/Biennial
Mentha arvensis	wild mint	Forb	Perennial
Muhlenbergia richardsonis	mat muhly	Graminoid	Perennial
Myosurus apetalus	bristly mousetail	Forb	Annual/Biennial
Navarretia intertexta	needleleaf navarretia	Forb	Annual/Biennial
Opuntia polyacantha	plains pricklypear	Shrub	Perennial
Pascopyrum smithii	western wheatgrass	Graminoid	Perennial
Penstemon spp.	beardtongue	Forb	Perennial
Plagiobothrys scouleri	sleeping popcornflower	Forb	Annual/Biennial
Plantago elongata	prairie plantain	Forb	Annual/Biennial
Poa palustris	fowl bluegrass	Graminoid	Perennial
Poa secunda	Sandberg bluegrass	Graminoid	Perennial
Polygonum spp.	knotweed	Forb	Perennial
Polygonum ramosissimum	bushy knotweed	Forb	Annual/Biennial
Ratibida columnifera	prairie coneflower	Forb	Perennial
Rumex salicifolius	willow dock	Forb	Perennial
Schedonnardus paniculatus	tumblegrass	Graminoid	Perennial
Schoenoplectus pungens	common threesquare	Graminoid	Perennial
Veronica peregrina	neckweed	Forb	Annual/Biennial
Vicia americana	American vetch	Forb	Perennial
Vulpia octoflora	sixweeks fescue	Graminoid	Annual/Biennial

Inventory data references

No field plots were available for this site. A review of the scientific literature and professional experience was used to approximate the plant communities for this provisional ecological site. Information for the state-and-transition model was obtained from the same sources. All community phases are considered provisional based on these plots and the sources identified in this ecological site description.

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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:**
