# Ecological site FX052X99X150
# Subirrigated (Sb)

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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.

## 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). 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 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 climatic 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: Spartina pectinata Great Plains Wet Meadow Alliance
• Association: Spartina pectinata - Carex spp. Wet Meadow 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) and Glaciated Northern Grasslands (42j)

Montana Riparian and Wetland Sites (Hansen et. al, 1995)
• Spartina pectinata Habitat Type and Symphoricarpos occidentalis Community Type

## Ecological site concept

This provisional ecological site occurs in all climatic zones of MLRA 52. Figure 1 illustrates the distribution of this ecological site based on current data. This ecological site generally occurs as a minor component in floodplain map units. Currently, it is not mapped consistently and is not equally represented in all soil survey areas. Therefore, the map is approximate, is not intended to be definitive, and is subject to change. Subirrigated is an ecological site of limited extent occurring sporadically throughout MLRA 52. It occurs on floodplains and stream terraces where a seasonal water table is present at a depth of 24 to 40 inches below the soil surface, especially during peak runoff periods. In some cases, the site may also receive additional moisture from flooding and stream overflow.

The distinguishing characteristics of this site are that it is located on floodplains and that it receives additional moisture from groundwater. 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 loam, silt loam, or silty clay loam. The soils typically have a mollic epipedon and are commonly stratified (USDA-NRCS, 2016) due to deposition of sediment from multiple flood events. Characteristic vegetation is prairie cordgrass (Spartina pectinata), western wheatgrass (Pascopyrum smithii), and sedges (Carex spp.). Shrubs may include chokecherry (Prunus virginiana), snowberry (Symphoricarpos spp.), and Wood's rose (*Rosa woodsii*).

## Associated sites

| | |
|---|---|
| FX052X99X061 | **Riparian Woodland (RW)**<br>This site is adjacent to the Subirrigated ecological site, typically on similar landscape positions, but where riparian woody plants are dominant. |
| FX052X99X060 | **Overflow (Ov)**<br>This site is adjacent to the Subirrigated ecological site, typically on higher terraces where ground water is greater than 40 inches below the surface and the primary moisture source is surface water. |
| FX052X99X084 | **Slough (Sl)**<br>This site is adjacent to the Subirrigated ecological site, typically in oxbows or channels where flooding is very frequent, the water table is shallow and persistent, and frequent ponding occurs. |
| FX052X99X092 | **Saline Subirrigated (Ssb)**<br>This site is adjacent to the Subirrigated ecological site in similar landscape positions but in areas where salts have accumulated due to geology, hydrology, or soil properties. |

## Similar sites

| | |
|---|---|
| FX052X99X061 | **Riparian Woodland (RW)**<br>This site differs from the Subirrigated ecological site in that it is dominated by riparian woody species. Shrubs and trees dominate the site in terms of cover and production. |
| FX052X99X084 | **Slough (Sl)**<br>This site differs from the Subirrigated ecological site in that depth to a water table is less than 24 inches and the site receives frequent long duration ponding. It is located in oxbows, old channels, or depressions on floodplains and is more productive. Vegetation is dominated by hydrophytes such as bulrush and cattail. |
| FX052X99X060 | **Overflow (Ov)**<br>This site differs from the Subirrigated ecological site in that it occupies higher terraces. It receives additional moisture primarily from surface water; whereas the Subirrigated ecological site receives it from groundwater. Depth to a water table is more than 40 inches. |
| FX052X99X092 | **Saline Subirrigated (Ssb)**<br>This site differs from the Subirrigated ecological site in that soils are saline, sodic, or saline-sodic (EC ≥ 4 or SAR ≥ 13). It supports more sodium-tolerant vegetation and is less productive. |

**Table 1. Dominant plant species**

| | |
|---|---|
| Tree | Not specified |
| Shrub | Not specified |
| Herbaceous | Not specified |

## Legacy ID

R052XY150MT

## Physiographic features

Subirrigated is an ecological site of limited extent occurring on floodplains, alluvial fans, and stream terraces.

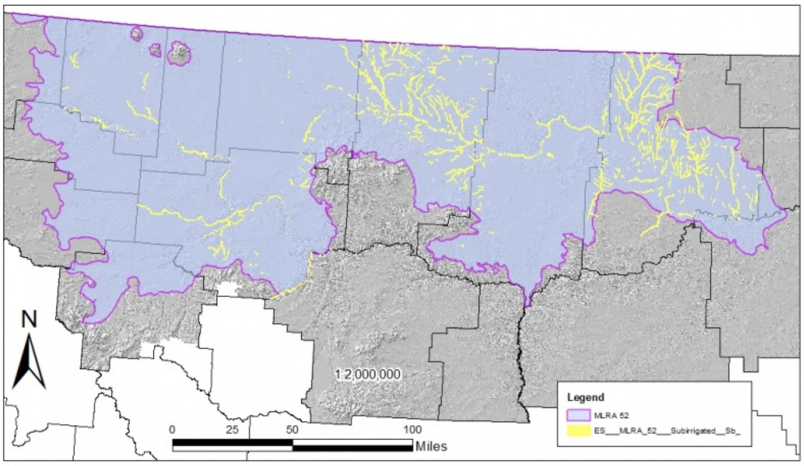


**Figure 1. Figure 1. General distribution of the Subirrigated ecological site by map unit extent.**

**Table 2. Representative physiographic features**

| | |
|---|---|
| Landforms | (1) Stream terrace<br>(2) Alluvial fan<br>(3) Flood plain |
| Flooding duration | Brief (2 to 7 days) |
| Flooding frequency | Rare to frequent |
| Elevation | 610–1,402 m |
| Slope | 0–2% |
| Water table depth | 61–102 cm |
| 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) | 330 mm |

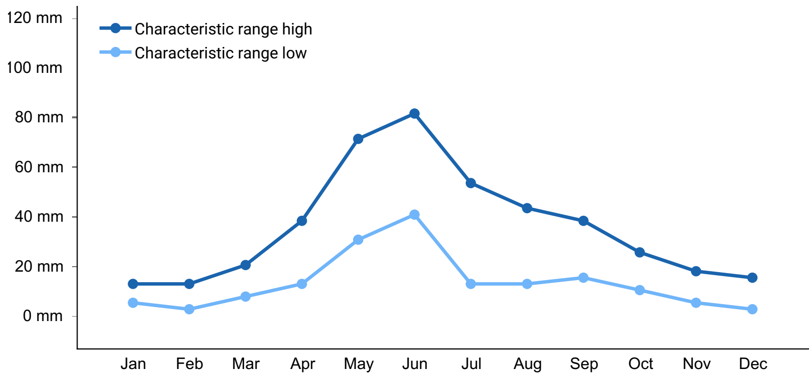


**Figure 2. Monthly precipitation range**

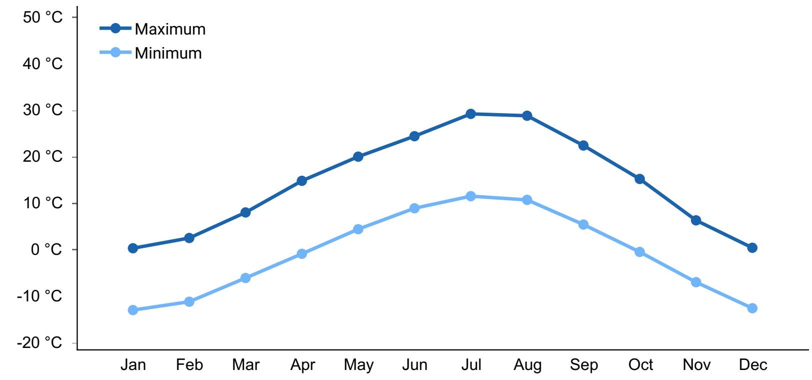


**Figure 3. Monthly average minimum and maximum temperature**

## 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 typically a floodplain site that receives additional moisture from groundwater and occasionally stream overflow. Hydrology is most similar to a lotic stream hydrogeomorphic (HGM) model (Tiner, 2003). It typically occurs on low gradient or intermittent gradient reaches, although many reaches on larger streams have been dammed. Typically, the site has groundwater connectivity with the stream channel at some time during the year and a seasonal groundwater table is present between 24 and 40 inches below the soil surface, particularly during spring. Groundwater dynamics are not well documented, but it is most likely a flow-through site. During spring flood events, the site may also be flooded for brief durations. Outside of peak precipitation cycles, the stream system typically exhibits a losing hydrology pattern and lower water tables.

## Soil features

The Subirrigated ecological site concept occurs as a minor component of floodplain map units throughout MLRA 52. Precise acreage is not known because the concept is not consistently mapped. The central concept for this ecological site is not represented by a soil series that is currently mapped in MLRA 52. The closest soil series currently mapped is the Enbar soil. This soil is in the Haplustolls great group. It has a mollic epipedon that is cumulic, meaning that it is 20 inches (50 cm) or more thick and has an irregular decrease in organic carbon. The

Enbar soil is in the fine-loamy family, meaning it contains between 18 and 35 percent clay in the particle-size control section. The mineralogy of this soil is mixed. The typical parent material for all soils in this concept is alluvial deposits. All soils in this site concept are endosaturated, meaning that they receive additional moisture from groundwater. Typically, soils in this concept would have a mollic epipedon, but would not be cumulic like the Enbar soil. The soil moisture regime for this ecological site concept is ustic, 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). Updated soil mapping is needed to better represent the central concept for this ecological site.

Surface horizon textures in this site are typically loam, silt loam, or silty clay loam. The underlying horizons are typically comprised of stratified alluvial deposits. They are characterized by many thin layers of sediment deposited by past flood events. Textures are highly variable and may range from sandy loam to clay loam. 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 2 to 4 percent organic matter, and moist colors vary from grayish brown (10YR 5/2) to very dark brown (10YR 2/2). Calcium carbonate equivalent is typically less than 15 percent throughout the soil profile. Soil pH classes are neutral to slightly alkaline in the surface horizon and slightly alkaline to moderately alkaline in the subsurface horizons. The soil depth class for this 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**

| | |
|---|---|
| Surface texture | (1) Loam<br>(2) Silt loam<br>(3) Clay loam |
| Drainage class | Well drained |
| Soil depth | 152–183 cm |
| Available water capacity (0-101.6cm) | 13.72–17.02 cm |
| Calcium carbonate equivalent (0-12.7cm) | 0–14% |
| Electrical conductivity (0-50.8cm) | 0–30 mmhos/cm |
| Sodium adsorption ratio (0-50.8cm) | 0–12 |
| Soil reaction (1:1 water) (0-101.6cm) | 6.6–8.4 |

## Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM) (Figure 2), 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 Subirrigated provisional ecological site in MLRA 52 consists of four states: The Reference State (1), the Altered State (2), the Invaded State (3), and the Cropland State (4). Plant communities associated with this ecological site evolved under the combined influences of climate, grazing, hydrology, 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.) also influenced this plant community (Salo et al., 2004). Grasshoppers and periodic outbreaks of Rocky Mountain locusts (Melanoplus spretus) also played an important role in the ecology of these communities (Lockwood, 2004).

The historic ecosystem experienced periodic 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, providing ideal conditions for seed germination and seedling establishment of non-native species.

Hydrology, particularly of groundwater, is another major ecological driver for this site. Depth and duration of the seasonal water table strongly influences species composition on this ecological site. Hydrologic alterations that modify the depth and the persistence of the seasonal water table may have a significant effect on species composition and production. In some cases, salinization may occur. On portions of this site the hydrology has been significantly altered by irrigation, major dams, and diversions. The implications of this alteration have not been fully studied and require further investigation.

Improper grazing of this site can result in a reduction in the cover of the palatable sedges and cool-season midgrasses (Hansen et al., 1995). Tall, warm-season rhizomatous grasses may sustain trampling damage. 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, 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. Over time species diversity, particularly of sedges and shrubs, can be significantly reduced by improper grazing. Periods of drought can also reduce sedges and rhizomatous grasses. Further degradation of the site due to improper grazing can result in low vigor of rhizomatous grasses and dominance of unpalatable shrubs and rushes. On some sites, sedges can be reduced to a single, unpalatable species (Hansen et al., 1995). Unpalatable forbs may also be common. This site is highly susceptible to invasion by non-native species. Perennial grasses such as non-native bluegrasses (Poa spp.), smooth brome (*Bromus inermis*), and reed canarygrass (*Phalaris arundinacea*) are the most common invasive species. These species appear to be able to invade any phase of the Reference State (1) and, once established, will displace native species and dominate the ecological functions of the site. Noxious weeds are also a major concern on this site. Leafy spurge (*Euphorbia esula*), Canada thistle (*Cirsium arvense*), and Russian knapweed (*Acroptilon repens*), also known as hardheads, are common on this site and capable of displacing native species.

The Subirrigated ecological site is often considered prime farmland. The large portions of this site has been converted to cropland, mostly for perennial hay. Common crop species include alfalfa (*Medicago sativa*), orchardgrass (*Dactylis glomerata*), creeping foxtail (*Alopecurus arundinaceus*), and grass/alfalfa mixes. Annual crops such as wheat, corn, and barley are occasionally planted as part of a rotation or when renovating hay fields. Sometimes irrigation is applied with flood irrigation being most common. Water is typically diverted from nearby streams and delivered to fields via canals. Extensive irrigation systems are in place on many parts of the Milk and Missouri River drainages. Irrigated cropland is extremely valuable in the region, and once the site is converted it is unlikely to be taken out of production.

The state-and-transition model (STM) (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 states not displayed in the STM diagram (Figure 2). 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.
The Reference State (1) contains two community phases. This state evolved under the combined influences of climate, grazing, fire, and floodplain hydrology. In general, this state was resilient to grazing and fire, although these factors could influence species composition in localized areas. Vegetation is characterized by tall and mid-statured rhizomatous grasses, sedges, and shrubs. Following disturbance, this state will exhibit an increase in rushes and

unpalatable forbs and a decrease in the diversity of sedges and shrubs. Vigor of rhizomatous grasses will decrease significantly.

Phase 1.1: Reference Community Phase

The Reference Community Phase (1.1) is characterized by rhizomatous grasses and sedges. Prairie cordgrass, a tall, warm-season rhizomatous grass, is common especially on wetter sites. The principle mid-statured rhizomatous grass is western wheatgrass. Other common grass species include, tufted hairgrass (*Deschampsia cespitosa*), rough bentgrass (*Agrostis scabra*), and slimstem reedgrass (*Calamagrostis stricta*). Sedges are abundant, particularly on wetter sites. Species diversity is high and may include blister sedge (*Carex vesicaria*), woolly sedge (*Carex pellita*), beaked sedge (*Carex rostrata*), and clustered field sedge (*Carex praegracilis*). Common forbs are goldenrod (Solidago spp.) and fringed willowherb (*Epilobium ciliatum*). Shrub cover varies from sparse, open stands to relatively dense, patchy stands, but species diversity is high. Common shrubs are snowberry, chokecherry, currant (Ribes spp), and Wood's rose (*Rosa woodsii*). The approximate species composition of the reference plant community is as follows:

Percent composition by weight*
Graminoids: 75-85%
Prairie Cordgrass
Rhizomatous Wheatgrass
Sedges
Tufted Hairgrass
Other Native Grasses

Perennial Forbs 5-10%
Shrubs/Subshrubs 5-15%

Estimated Total Annual Production (lbs/ac)*
Low - Insufficient data
Representative Value - 2,400
High - Insufficient data
*Estimate based on current observation – subject to revision.

Phase 1.2: Rhizomatous Grass-Rush Community Phase

The Rhizomatous Grass-Rush Community Phase (1.2) is characterized by a decrease in rhizomatous grasses, an increase in rushes, and declining diversity of sedges and shrubs. Rhizomatous wheatgrasses are common, but their abundance and production are beginning to decline. Prairie cordgrass is also declining in vigor due to trampling damage. Less palatable species such as Baltic rush (*Juncus arcticus* ssp. littoralis) are common and increasing. Sedge diversity is declining and the predominant species is Nebraska sedge (*Carex nebrascensis*). Nebraska sedge typically increases with grazing pressure and can replace other sedge species under continuous grazing (Hansen et al., 1995). Unpalatable forbs such as American Licorice (*Glycyrrhiza lepidota*) and white sagebrush (*Artemisia ludoviciana*), also known as cudweed sagewort, also increase in this phase. Snowberry is the predominant shrub, although chokecherry and currant may remain at low cover.

Community Phase Pathway 1.1a

Drought, improper grazing management, or a combination of these factors can shift the Reference Community Phase (1.1) to the Rhizomatous Grass-Rush Community Phase (1.2). These factors favor a decrease in rhizomatous grasses, an increase in rushes, and declining species diversity (Hansen et al., 1995).

Community Phase Pathway 1.2a

Normal or above-average precipitation and proper grazing management can shift the Rhizomatous Grass-Rush Community Phase (1.2) to the Reference Community Phase (1.1). These factors favor a decrease in rushes, an increase in rhizomatous grasses, and increased species diversity.

Transition T1A

Continued improper grazing practices weaken the resilience of the Reference State (1) and drive its transition to the Altered State (2). The Reference State (1) transitions to the Altered State (2) when rhizomatous grasses become rare and species diversity is severely reduced. Snowberry, Baltic rush, and unpalatable forbs such as American licorice dominate the plant community.

Transition T1B
The Reference State (1) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade. Kentucky bluegrass and smooth brome are widespread invasive species in the northern Great Plains (Toledo et al., 2014; Dekeyser et al., 2013). Close proximity to a seed source combined with favorable growing conditions are thought to be the major contributing factors to invasion on this site. Decreased vigor of native species may also increase susceptibility to invasion.

Transition T1C
Tillage or application of herbicide followed by seeding of cultivated crops, such as wheat, barley, or introduced hay, transitions the Reference State (1) to the Cropland State (4).

State 2: Altered State
The Altered State (2) consists of one community phase. The dynamics of this state are driven by long term improper grazing management. Snowberry and rushes increase at the expense of rhizomatous grasses and palatable shrubs. Species diversity of sedges and shrubs is greatly reduced, often consisting of only one or two species. Proper grazing management can reduce rushes cover and increase the cover of rhizomatous wheatgrasses although this recovery may take decades.

Phase 2.1: Snowberry/Rush Community Phase
The Snowberry/Rush Community Phase (2.1) occurs when site conditions decline due to long-term improper grazing. Rhizomatous grasses such as prairie cordgrass and western wheatgrass have been significantly reduced and have poor vigor. They have been replaced by rushes and unpalatable forbs such as American licorice and cudweed sagewort. Shrub diversity is low and is typically dominated by snowberry, although Wood's rose may also occur at low cover. Sedge diversity is also low. In some cases, a monoculture of Nebraska sedge may occur. Under continuous season long grazing Nebraska sedge increases, replacing other sedge species and forming a dense root mat. This dense mat is resistant to grazing and replacement by other sedge species (Hansen et al., 1995). The decreased vigor of native grasses may make this phase more susceptible to invasion by non-native species such as Kentucky bluegrass (*Poa pratensis*), smooth brome, and noxious weeds.

Transition T2A
Tillage or application of herbicide followed by seeding of cultivated crops, such as wheat, barley, or introduced hay, transitions the Altered State (2) to the Cropland State (4).

Transition T2B
The Altered State (2) transitions to the Invaded State (3) when aggressive perennial grasses or noxious weeds invade. Kentucky bluegrass and smooth brome are widespread invasive species in the northern Great Plains (Toledo et al., 2014; Dekeyser et al., 2013). Close proximity to a seed source combined with favorable growing conditions are thought to be the major contributing factors to invasion on this site. Decreased vigor of native species may also increase susceptibility to invasion.

Restoration Pathway R2A
A reduction in livestock grazing pressure alone may not be sufficient to reduce the cover of snowberry and rushes in the Altered State (2). Nebraska sedge can also resist displacement by other species (Hansen et al., 1995). Intensive management treatments such as revegetation and brush management may be necessary. Therefore, returning the Altered State (2) to the Reference State (1) can require considerable cost, energy, and time.

State 3: Invaded State
The Invaded State (3) occurs when invasive plant species invade adjacent native grassland communities. Reduced plant species diversity, simplified structural complexity, and altered biologic processes result in a state that is substantially departed from the Reference State (1). The Subirrigated ecological site is highly susceptible to invasion, and the Invaded State (3) is very common. Additional moisture from groundwater creates favorable growing conditions and occasional flooding readily transports seed onto the site from upstream. It thereby creates ideal conditions for invasion by non-native species. A large portion of the uncultivated acres of this ecological site exhibit some degree of invasion by non-native species. In general, the Subirrigated ecological site is more susceptible to degradation by invasive species than by any other mechanism. Even slight disturbances can be sufficient for invasive species to establish.

Perennial grasses, such as Kentucky bluegrass, smooth brome, and reed canarygrass are the most common concerns. Kentucky bluegrass and smooth brome 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 allopathic 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). They appear to be capable of invading any phase of the Reference State (1), regardless of grazing management practices, and have been found to substantially increase under long-term grazing exclusion (DeKeyser et al., 2009, 2013; Grant et al., 2009). Effects on soil quality 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). Reed canarygrass most commonly occurs on wetter portions of this ecological site. It is a vigorous sod-forming native grass species that frequently displaces desirable vegetation when it invades a site. European common reed (*Phragmites australis* subsp. australis) has yet been documented on this ecological site and but it may also become a concern if it were to establish on this ecological site.

Although noxious weeds are not widespread in most of MLRA 52, they are a common concern on the Subirrigated ecological site. Leafy spurge, Russian knapweed, and Canada thistle are the most common noxious weeds. These species are very aggressive perennials that typically displace native species and dominate the ecological function when they invade a site. Sometimes, 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 T3A
Tillage or application of herbicide followed by seeding of cultivated crops, such as wheat, barley, or introduced hay, 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. Deep, fertile soils and favorable moisture conditions make the Subirrigated ecological site prime farmland. Additionally, its proximity to perennial streams make it possible to apply irrigation. Because of this, many acres of the Subirrigated ecological site have been converted to farmland, particularly along the major rivers. It is most commonly planted to non-native perennial species for production of hay. Common species include alfalfa, orchardgrass, creeping foxtail, and grass/alfalfa mixes. Annual crops such as wheat and barley are occasionally planted in rotation with perennial species at 5- to 15-year intervals. In some cases, irrigation is applied in an attempt to increase production. Flood irrigation is most common but center pivot sprinklers are used in some areas. Several major storage reservoirs and large networks of irrigation canals are present in much of the Milk and Missouri River valleys. Cropping and irrigation projects have vastly altered vegetation and hydrology on much of the Subirrigated ecological site. Once the site is converted to production agriculture, land values increase significantly and it is unlikely that the site will be converted back to natural vegetation.

## State and transition model

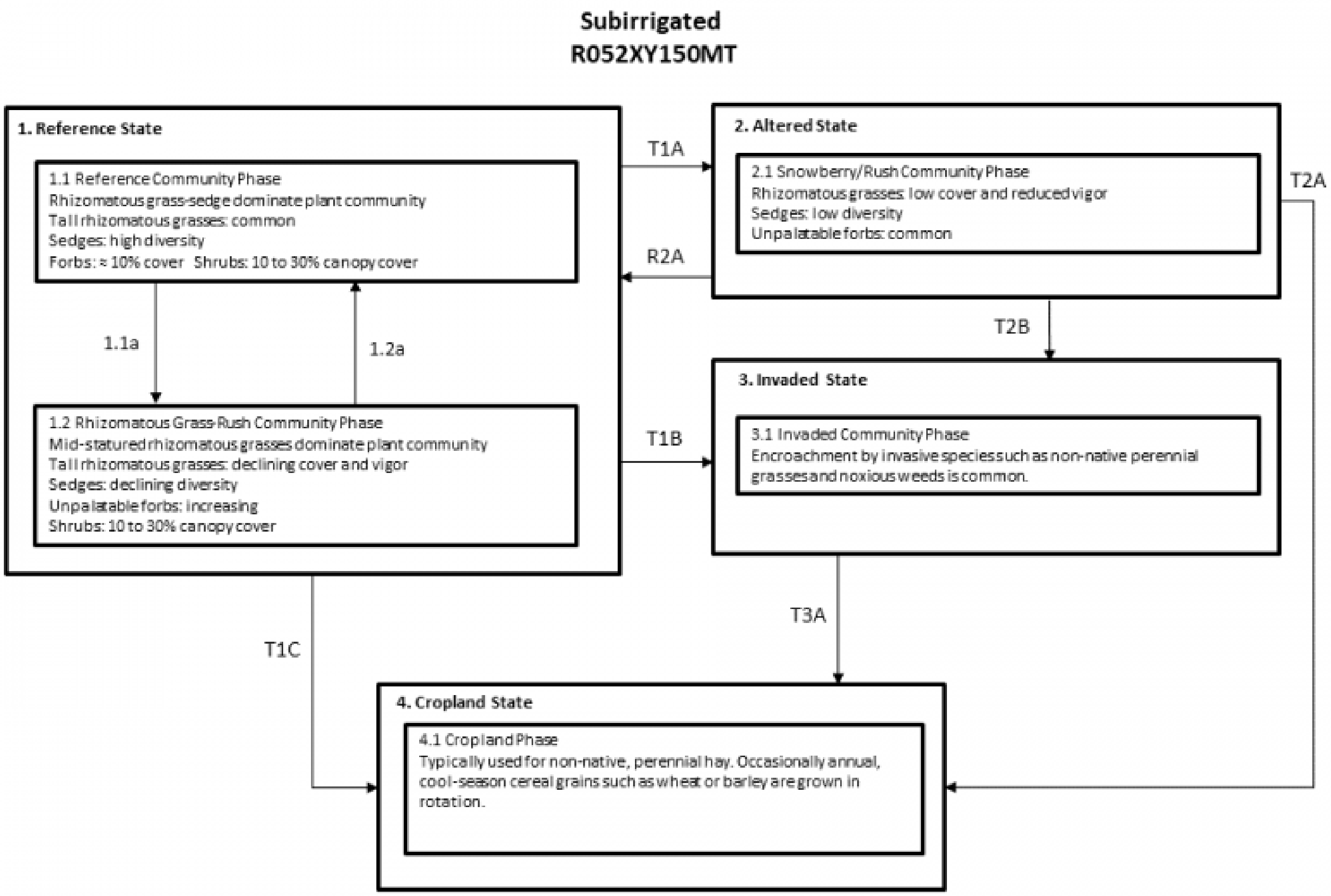


*Figure 2. State-and-transition model diagram.*

**Subirrigated**
**R052XY150MT**

**Legend**

1.1a - drought, improper grazing management

1.2a - normal or above-normal spring moisture, proper grazing management

T1A - continued improper grazing

R2A - proper grazing management, normal or above-normal moisture, revegetation (management intensive and costly)

T1B, T2B - introduction of non-native invasive species (introduced grasses and/or noxious weeds)

T1C, T2A, T3A - tillage or herbicide application and seeding of annual crops or non-native hayland (may be combined with irrigation practices)

*Figure 2 (continued). State-and-transition model legend.*

## Inventory data references

One low-intensity plot was available for this site. This plot, in conjunction with a review of the scientific literature and professional experience, was used to approximate the reference plant community. Information for other states and community phases was obtained from a review of the scientific literature and professional experience. All community phases are considered provisional based on these plots and the sources identified in this ecological site description.

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## Approval

Scott Brady, 6/28/2019

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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:**