

## Ecological site FX052X02X756 Woody Draw (Wd) Moist Grassland

Last updated: 8/28/2019  
Accessed: 05/19/2024

### 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, 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 Illinoian age. Due to erosion and dissection of the landscape, many of these areas have steeper slopes and more exposed bedrock than areas glaciated during the Wisconsin age (Fullerton and Colton, 1986).

While much of the rangeland in the aridic ustic portion of MLRA 52 is classified as belonging to the “dry grassland” climatic zone, sites in portions of southern MLRA 52 may belong to the “dry shrubland” climatic zone. The dry shrubland zone represents the northernmost extent of the big sagebrush (*Artemisia tridentata*) steppe on the Great Plains. 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 typical 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: Moist 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)
- o Alliance: *Crataegus douglasii* - *Crataegus succulenta* Shrubland Alliance

- Association: *Crataegus douglasii* - (*Crataegus chrysocarpa*) Shrubland
- o Alliance: *Prunus virginiana* - *Symphoricarpos occidentalis* - *Amelanchier alnifolia* Great Plains Shrubland Alliance
- Association: *Prunus virginiana* Great Plains Shrubland

#### 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)

Cherry Patch Moraines (42m)

Milk River Pothole Upland (42n)

### Ecological site concept

This provisional ecological site occurs in the Moist 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. Woody Draw Moist Grassland is a somewhat extensive ecological site on till plains and hillslopes in MLRA 52. It is nearly always a minor component in soil map units, 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 and that it supports a predominantly woody plant community. Soils for this ecological site are typically very deep (more than 60 inches) and derived from alluvium or till. Soil textures in the upper 4 inches are typically loam, silt loam or clay loam. Typically, the soils are pachic. This site is more productive than surrounding sites due to the increased available moisture and sheltering topography. Characteristic vegetation is black hawthorn (*Crataegus douglasii*), chokecherry (*Prunus virginiana*), and serviceberry (*Amelanchier alnifolia*). The principal grasses on this site are western wheatgrass (*Pascopyrum smithii*) and cool-season bunchgrasses.

### Associated sites

FX052X02X062	<b>Swale (Se) Moist Grassland</b> The Swale Moist Grassland ecological site is found adjacent to the Woody Draw Moist Grassland ecological site on similar landforms. It is typically downslope from the Woody Draw Moist Grassland ecological site and generally occurs on broader, less sheltered swale microfeatures.
FX052X02X032	<b>Loamy (Lo) Moist Grassland</b> The Loamy Moist Grassland ecological site is found upslope from and commonly surrounding the Woody Draw Moist Grassland ecological site. It is typically found in summit positions where the upper 4 inches of soil contains 18 to 35 percent clay.
FX052X02X040	<b>Loamy-Steep (Lostp) Moist Grassland</b> The Loamy Steep Moist Grassland ecological site is found on slopes of 15 percent or greater upslope from the Woody Draw Moist Grassland ecological site. It occurs on backslope positions whereas the Woody Draw Moist Grassland ecological site occurs on toeslopes on swale microfeatures where surface runoff is concentrated..
FX052X02X029	<b>Limy-Steep (Lystp) Moist Grassland</b> The Limy Steep Moist Grassland ecological site is found on slopes of 15 percent or greater upslope from the Woody Draw Moist Grassland ecological site. It occurs on convex backslope positions whereas the Woody Draw Moist Grassland ecological site occurs on swale microfeatures where surface runoff is concentrated.

### Similar sites

FX052X99X061	<b>Riparian Woodland (RW)</b> This site differs from Woody Draw Moist Grassland ecological site in that it is on flood plains rather than upland swales. It generally is on stream terraces adjacent to a losing stream reach. Woody vegetation typically contains obligate riparian species such as sandbar willow and plains cottonwood.
FX052X02X062	<b>Swale (Se) Moist Grassland</b> This site differs from the Woody Draw Moist Grassland ecological site in that it is dominated by herbaceous species. Bunchgrasses dominate the site in terms of cover and production.
FX052X02X032	<b>Loamy (Lo) Moist Grassland</b> This site differs from the Woody Draw Moist Grassland ecological site in that it is in higher topographical positions that do not receive additional moisture and it does not support woody vegetation whereas the Woody Draw Moist Grassland ecological site is in the bottoms of coulees or swales and receives additional moisture.

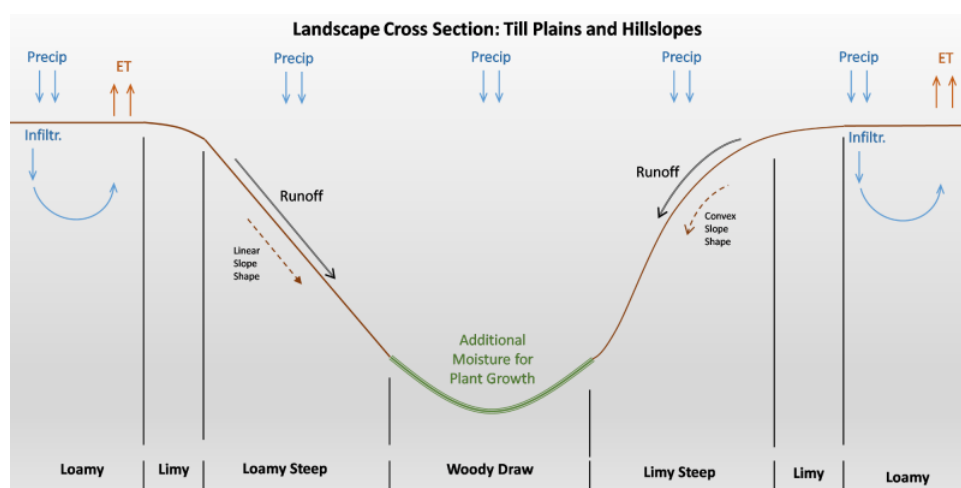


Figure 2.

Table 1. Dominant plant species

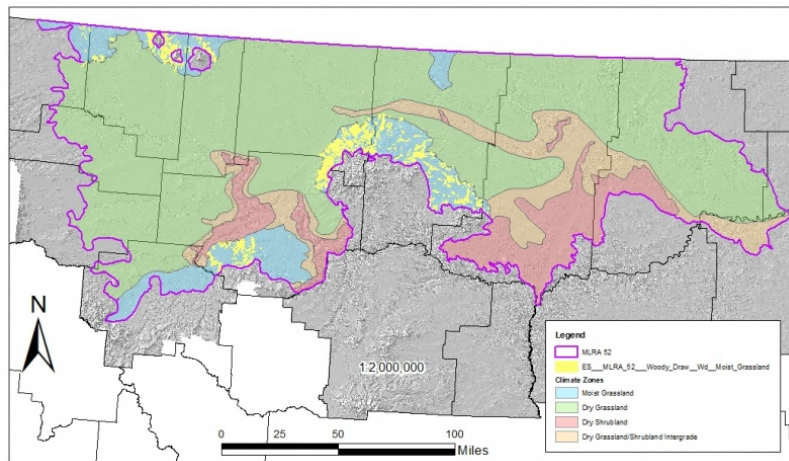
Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

## Legacy ID

R052XY756MT

## Physiographic features

Woody Draw Moist Grassland is a somewhat extensive ecological site occurring in the moist areas of MLRA 52. It is found on till plains and hillslopes; primarily at higher elevations near the various mountain ranges and the Sweetgrass Hills. This site is common, but typically occurs as a minor component of most map units. It is found on swale microfeatures that receive additional moisture via surface runoff from adjacent sites. It typically occurs in the narrowest, most sheltered swales in a particular mapunit and is most common on northerly aspects. Slopes can vary but this ecological site most commonly occurs on slopes between 4 and 25 percent. It is believed that sheltering due to topography and aspect promotes the growth of woody vegetation, but the precise factors are unknown at this time. Further investigation of influencing physiographic features is necessary.



**Figure 3. Figure 1. Map units containing Woody Draw Moist Grassland ecological site as a minor component (<10% map unit composition).**

**Table 2. Representative physiographic features**

Landforms	(1) Till plain > Hillslope > Swale
Elevation	1,097–1,399 m
Slope	4–25%
Aspect	NW, N, NE

## 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 110 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 years. Annual precipitation ranges from 13 to 17 inches, 70 to 80 percent of which 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 a reaction of plants to a “false spring” (Oard, 1993).

**Table 3. Representative climatic features**

Frost-free period (average)	110 days
Freeze-free period (average)	135 days
Precipitation total (average)	381 mm

## Climate stations used

- (1) GERALDINE [USC00243445], Geraldine, MT
- (2) GOLDBUTTE 7 N [USC00243617], Sunburst, MT

## Influencing water features

This is a semi-arid, upland ecological site and the water budget is normally contained within the soil pedon. 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.

## Soil features

The central concept for this ecological site is best represented by the Obrien soil, which occurs on swale microfeatures. This soil is in the Haplustolls great group and is characterized by a mollic epipedon and the lack of an argillic horizon. It is also classified as pachic, meaning the mollic epipedon is at least 16 inches thick. The Obrien soil has mixed mineralogy and is in the fine-loamy particle-size family, meaning that it contains between 18 and 35 percent clay in the particle-size control section. The typical parent material of all soils in this ecological site concept is alluvium or till. The soil moisture regime for all soils in this ecological site concept is typic 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).

Surface textures found in this site are most commonly loam, silt loam or clay loam and typically contain between 25 to 35 percent clay. The underlying horizons typically contain 18 to 35 percent clay and have loam or clay loam. Organic matter content in the surface horizon typically ranges from 2 to 6 percent, and moist colors vary from dark brown (10YR 3/3) to very dark brown (10YR 2/2). The surface horizon of these soils does not typically react with hydrochloric acid. Calcium carbonate equivalent is typically less than 10 percent throughout the soil profile. In the upper 20 inches, electrical conductivity is less than 4 and the sodium absorption ratio is less than 13. Soil pH classes are neutral in the surface horizon and moderately to strongly alkaline in the subsurface horizons. The soil depth class for this 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) Till
Surface texture	(1) Loam (2) Silt loam (3) Clay loam
Drainage class	Well drained
Soil depth	152–183 cm
Available water capacity (0-101.6cm)	16.76–20.57 cm
Calcium carbonate equivalent (0-12.7cm)	0–9%
Electrical conductivity (0-50.8cm)	0–3 mmhos/cm
Sodium adsorption ratio (0-50.8cm)	0–12
Soil reaction (1:1 water) (0-101.6cm)	6.6–9
Subsurface fragment volume <=3" (0-50.8cm)	0–34%
Subsurface fragment volume >3" (0-50.8cm)	0–34%

## Ecological dynamics

The information in this ecological site description, including the state-and-transition model (STM) (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 Woody Draw provisional ecological site in MLRA 52 Moist Grassland consists of three states: The Reference State (1), the Herbaceous Understory State (2), and the Invaded State (3). 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 (*Antilocapra americana*), elk (*Cervus canadensis*), and deer (*Odocoileus* spp.) were also common. Additionally, small mammals such as prairie dogs (*Cynomys* spp.) and ground squirrels (*Urocitellus* spp.) influenced this plant community (Salo et al., 2004). Grasshoppers and periodic outbreaks of Rocky Mountain locusts (*Melanoplus spretus*) 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 Woody Draw Moist Grassland appears to be resilient to fire and the primary effects fire return are believed to be a temporary reduction in shrub cover. However, fire ecology has not been studied in detail and further investigation is needed. 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 brome (*Bromus arvensis*), better known as Japanese brome (Whisenant, 1990). These species have become naturalized in relatively undisturbed grasslands (Ogle et al., 2003; Harmony, 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 of shrub diversity and an increase in less palatable shrubs (Hansen et al., 1995). Mid-statured bunchgrasses are eliminated or nearly so. Rhizomatous wheatgrasses, particularly western wheatgrass (*Pascopyrum smithii*), appear to be relatively resistant to grazing on this site, presumably due to the increased moisture availability and their rhizomatous nature. 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. Further degradation of the site due to improper grazing will eventually eliminate nearly all shrubs and result in an open, decadent stand of black hawthorn in the top canopy with an herbaceous dominated understory. Reduced vigor of rhizomatous wheatgrasses and an increase in unpalatable forbs such as white sagebrush, more commonly known as cudweed sagewort (*Artemisia ludoviciana*) may also occur. Once the stand has transitioned from a shrub-dominated understory to an herbaceous dominated understory, returning it to its former state is very difficult (Hansen et al., 1995). The effects of drought on this ecological site are not well understood at this time and further investigation is needed.

Due to the steep and broken topographic setting, this ecological site is not suitable for cropland. In general, this site has remained intact, although many acres have been invaded by non-native species. Introduced bluegrasses (*Poa* spp.) are the most common invasive species, but smooth brome (*Bromus inermis*) and noxious weeds can also be a concern in some areas. These species are widespread throughout the Northern Great Plains and appear able to invade any phase of the Reference State (1) (Toledo et al., 2014). Once established, they will displace native species and dominate the ecological functions of the 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 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 (1) contains two community phases. This state evolved under the combined influences of climate, grazing, and fire. Climatic variation generally has the greatest influence on cover and production. In general, this state was resilient to grazing, however, heavy grazing pressure could influence species composition in localized areas. This state is believed to be highly resilient to fire. All major shrubs species in this state are capable of re-sprouting from crowns or roots following fire (Fryer, 1997; Johnson, 2000; Lorenzo and Moore, 2006; Hauser, 2007). Woody vegetation would likely recover from fire in 3 years or less, however further study of fire dynamics is needed. Vegetation is characterized by three primary layers: tall shrubs, short shrubs, and herbaceous species.

##### Phase 1.1: Mixed Shrub Phase

The Mixed Shrub Community Phase (1.1) is characterized by a diverse community of tall and short shrubs. The primary tall shrub species are black hawthorn, chokecherry, and serviceberry. The short shrub layer is also diverse and may include western snowberry (*Symphoricarpos occidentalis*), gooseberry (*Ribes* spp.), woods rose (*Rosa woodsii*), and raspberry (*Rubus idaeus*). The herbaceous layer consists of bunchgrasses and rhizomatous wheatgrasses. The predominant bunchgrasses are green needlegrass (*Nassella viridula*) and western porcupinegrass (*Hesperostipa curisetia*). Rough fescue (*Festuca campestris*) becomes common as mean annual precipitation increases. Rhizomatous wheatgrasses may include western wheatgrass or thickspike wheatgrass (*Elymus lanceolatus*). Common forbs are goldenrod (*Solidago* spp.), purple meadow rue (*Thalictrum dasycarpum*), and Northern bedstraw (*Galium boreale*). Though not abundant, western poison ivy (*Toxicodendron rydbergii*) frequently occurs at low cover. The approximate cover by species is as follows:

##### Percent canopy cover by species\*

Tall Shrubs 70-90%

Black Hawthorn (50%)

Chokecherry (10-30%)

Serviceberry (10-30%)

Short Shrubs 20-30%

Western Snowberry (10-20%)

Woods Rose (1-5%)

Other Native Shrubs (5%)

##### Percent foliar cover by species\*

Bunchgrasses 30%

Green Needlegrass (15-30%)

Western Porcupine Grass (0-15%)

Other Native Bunchgrasses (0-10%)

Rhizomatous Wheatgrass 10%

Other Native Grasses 5%

Perennial Forbs 15%

##### Estimated Total Annual Production (lbs/ac)\*

Low - Insufficient data

Representative Value - 3500

High - Insufficient data

\* Estimated based on current data – subject to revision

##### Phase 1.2: At-Risk Community Phase



The At-Risk Community Phase (1.2) occurs when the site condition declines due to improper grazing management. It is characterized by a decline in shrub diversity in both the tall species and the short species. The predominant tall shrub species is black hawthorn. Palatable shrubs such as chokecherry and serviceberry are rare or absent. The short shrub layer is predominantly snowberry, although wood's rose may also be common on some sites. Mid-statured bunchgrasses, particularly green needlegrass, have been eliminated or nearly so. The herbaceous plant community is dominated by rhizomatous wheatgrasses, primarily western wheatgrass, and unpalatable forbs such as cudweed sagewort and American licorice (*Glycyrrhiza lepidota*) are increasing.

#### Community Phase Pathway 1.1a

Improper grazing management can shift the Mixed Shrub Phase (1.1) to the At-Risk Community Phase (1.2).

#### Community Phase Pathway 1.2a

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

#### Transition T1A

Prolonged improper grazing practices weaken the resilience of the Reference State (1) and drive its transition to the Herbaceous Understory State (2). The Reference State (1) transitions to the Herbaceous Understory State (2) when shrub reproduction becomes rare and the stand becomes open and decadent.

#### Transition T1B

The Reference State (1) transitions to the Invaded State (2) when aggressive perennial grasses or noxious weeds invade. The most common concerns are introduced bluegrasses and smooth brome, which are 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 invasion. Studies have also shown that exclusion of grazing and fire favors invasive bluegrass species (DeKeyser et al., 2013). In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference State.

#### State 2: Herbaceous Understory State

The Herbaceous Understory State (2) consists of one community phase. The dynamics of this state are driven by long-term improper grazing management practices. It is characterized by an herbaceous dominated understory community with an open shrub canopy. Once the stand has transitioned from a shrub-dominated understory to an herbaceous dominated understory, returning it to its former state is very difficult (Hansen et al., 1995).

#### Phase 2.1: Hawthorn/Wheatgrass Community Phase

The Hawthorn/Wheatgrass Community Phase (2.1) occurs when the shrub layers have been largely removed due to prolonged improper grazing practices. The top canopy typically consists of an open, decadent black hawthorn stand. Short shrubs such as snowberry and gooseberry have been eliminated or nearly so and the understory layer is dominated by herbaceous species. The predominant grass species is western wheatgrass, but vigor is greatly reduced. Unpalatable forbs such as cudweed sagewort and American licorice are common.

#### Restoration Pathway R2A

A change in management alone may not be sufficient to restore the Herbaceous Understory State (2) to the Reference State (1). Tree/shrub planting, normal or above-normal moisture, and proper grazing management can transition the Herbaceous Understory State (2) back to the Reference State (1). These restoration methods are labor intensive and costly and may not be a practical in all situations.

#### State 3: Invaded State

The Invaded State (3) occurs when invasive plant species invade adjacent native plant communities. Introduced bluegrasses, such as Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*Poa compressa*), are the most widespread concerns. Smooth brome is less widespread, but it can also become a concern on this site, particularly in wetter areas. 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). 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). Invasive grass species appear to be capable of invading any phase of the Reference State, 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). 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 weeds such as houndstongue have 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.

## State and transition model

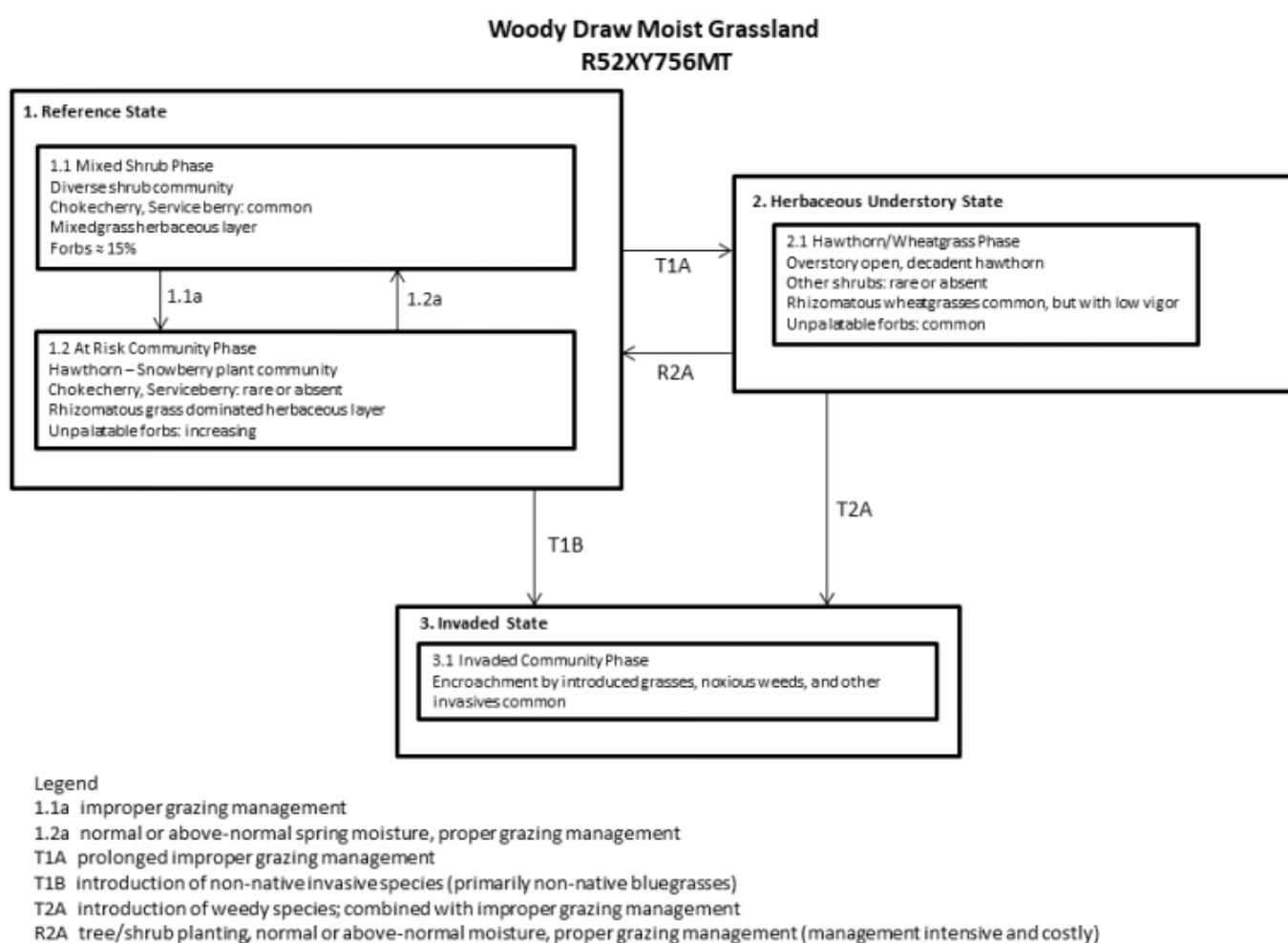


Figure 2. State-and-transition diagram

## Inventory data references

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

## Other references

Adams, B.W., et al. 2013. Rangeland plant communities for the mixedgrass natural subregion of Alberta. Second approximation. Rangeland Management Branch, Policy Division, Alberta Environment and Sustainable Resource

Development, Lethbridge, Pub. No. T/039.

Anderson, R.C. 2006. Evolution and origin of the central grassland of North America: Climate, fire, and mammalian grazers. *Journal of the Torrey Botanical Society* 133:626-647.

Baskin, J.M., and C.C. Baskin. 1981. Ecology of germination and flowering in the weedy winter annual grass *Bromus japonicus*. *Journal of Range Management* 34:369-372.

Biondini, M.E., and L. Manske. 1996. Grazing frequency and ecosystem processes in a northern mixed prairie, USA. *Ecological Applications* 6:239-256.

Biondini, M.E., B.D. Patton, and P.E. Nyren. 1998. Grazing intensity and ecosystem processes in a northern mixed-grass prairie, USA. *Ecological Applications* 8:469-479.

Bloom-Cornelius, I.V. 2011. Vegetation response to fire and domestic and native ungulate herbivory in a Wyoming big sagebrush ecosystem. M.S. thesis, Oklahoma State University. Stillwater, OK.

Bragg, T.B. 1995. The physical environment of the Great Plains grasslands. In: A. Joern and K.H. Keeler (eds.) *The Changing Prairie*, Oxford University Press, Oxford, pp. 49-81.

Branson, D.H., and G.A. Sword. 2010. An experimental analysis of grasshopper community responses to fire and livestock grazing in a northern mixed-grass prairie. *Environmental Entomology* 39:1441-1446.

Bylo, L.N., N. Koper, and K.A. Molloy. 2014. Grazing intensity influences ground squirrel and American badger habitat use in mixed-grass prairies. *Rangeland Ecology and Management* 67:247-254.

Christian, J.M., and S.D. Wilson. 1999. Long-term ecosystem impacts of an introduced grass in the Northern Great Plains. *Ecology* 80:2397-2407.

Clarke, S.E., E.W. Tisdale, and N.A. Skoglund. 1947. The effects of climate and grazing practices on short-grass prairie vegetation in southern Alberta and southwestern Saskatchewan. Canadian Department of Agriculture Technical Bulletin No. 46.

Cleland, D.T., et al. 1997. National hierarchical framework of ecological units. In: M.S. Boyce and A. Haney (eds.) *Ecosystem Management Applications for Sustainable Forest and Wildlife Resources*, Yale University Press, New Haven, CT.

Cooper, S.V., C. Jean, and P. Hendricks. 2001. Biological survey of a prairie landscape in Montana's glaciated plains. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT.

Cooper, S.V., and W.M. Jones. 2003. Site descriptions of high-quality wetlands derived from existing literature sources. Report to the Montana Department of Environmental Quality. Montana Natural Heritage Program, Helena, MT.

Coupland, R.T. 1950. Ecology of the mixed prairie of Canada. *Ecological Monographs* 20:271-315.

Coupland, R.T. 1958. The effects of fluctuations in weather upon the grasslands of the Great Plains. *Botanical Review* 24:273-317.

Coupland, R.T. 1961. A reconsideration of grassland classification in the Northern Great Plains of North America. *Journal of Ecology* 49:135-167.

Coupland, R.T., and R.E. Johnson. 1965. Rooting characteristics of native grassland species in Saskatchewan. *Journal of Ecology* 53:475-507.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. US Fish and Wildlife Service FWS/OBS, 79(31), 131.

- Crowe, E., and G. Kudray. 2003. Wetland Assessment of the Whitewater Watershed. Report to U.S. Bureau of Land Management, Malta Field Office. Montana Natural Heritage Program, Helena, MT.
- Davis, S.K., R.J. Fisher, S.L. Skinner, T.L. Shaffer, and R.M. Brigham. 2013. Songbird abundance in native and planted grassland varies with type and amount of grassland in the surrounding landscape. *Journal of Wildlife Management* 77:908-919.
- DeKeyser, E.S., M. Meehan, G. Clambey, and K. Krabbenhoft. 2013. Cool season invasive grasses in northern Great Plains natural areas. *Natural Areas Journal* 33:81-90.
- DeKeyser, S., G. Clambey, K. Krabbenhoft, and J. Ostendorf. 2009. Are changes in species composition on central North Dakota rangelands due to non-use management? *Rangelands* 31:16-19.
- Derner, J.D., and R.H. Hart. 2007. Grazing-induced modifications to peak standing crop in northern mixed-grass prairie. *Rangeland Ecology and Management* 60:270-276.
- Derner, J.D., and A.J. Whitman. 2009. Plant interspaces resulting from contrasting grazing management in northern mixed-grass prairie: Implications for ecosystem function. *Rangeland Ecology and Management* 62:83-88.
- Derner, J.D., W.K. Lauenroth, P. Stapp, and D.J. Augustine. 2009. Livestock as ecosystem engineers for grassland bird habitat in the western Great Plains of North America. *Rangeland Ecology and Management* 62:111-118.
- Dix, R.L. 1960. The effects of burning on the mulch structure and species composition of grasslands in western North Dakota. *Ecology* 41:49-56.
- Dormaar, J.F., and S. Smoliak. 1985. Recovery of vegetative cover and soil organic matter during revegetation of abandoned farmland in a semiarid climate. *Journal of Range Management* 38:487-491.
- Dormaar, J.F., and W.D. Willms. 1990. Effect of grazing and cultivation on some chemical properties of soils in the mixed prairie. *Journal of Range Management* 43:456-460.
- Dormaar, J.F., B.W. Adams, and W.D. Willms. 1994. Effect of grazing and abandoned cultivation on a *Stipa-Bouteloua* community. *Journal of Range Management* 47:28-32.
- Dormaar, J.F., M.A. Naeth, W.D. Willms, and D.S. Chanasyk. 1995. Effect of native prairie, crested wheatgrass (*Agropyron cristatum*) and Russian wildrye (*Elymus junceus*) on soil chemical properties. *Journal of Range Management* 48:258-263.
- Fansler, V.A., and J.M. Mangold. 2010. Restoring native plants to crested wheatgrass stands. *Restoration Ecology* 19:16-23.
- Federal Geographic Data Committee. 2008. The National Vegetation Classification Standard, Version 2. FGDC Vegetation Subcommittee. FGDC-STD-005-2008 (Version 2). pp. 126.
- Fryer, J. L. 1997. *Amelanchier alnifolia*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/shrub/amealn/all.html> accessed (3/23/2017).
- Fullerton, D.S., and R.B. Colton. 1986. Stratigraphy and correlation of the glacial deposits on the Montana Plains. U.S. Geological Survey.
- Fullerton, D.S., R.B. Colton, C.A. Bush, and A.W. Straub. 2004. Map showing spatial and temporal relations of mountain and continental glaciations on the northern plains, primarily in northern Montana and northwestern North Dakota. U.S. Geologic Survey pamphlet accompanying Scientific Investigations Map 2843.
- Fullerton, D.S., R.B. Colton, and C.A. Bush. 2013. Quaternary geologic map of the Shelby 1° x 2° quadrangle, Montana: U.S. Geological Survey Open-File Report 2012–1170, scale 1:250,000.
- Galatowitsch, S.M., and A.G. Van der Valk. 1996. The vegetation of restored and natural prairie wetlands.

- Gilbert, M.C., P.M. Whited, E.J. Clairain Jr., and R.D. Smith. 2006. A regional guidebook for applying the hydrogeomorphic approach to assessing wetland functions of prairie potholes. U.S. Army Corps of Engineers Final Report, Washington, DC.
- Grant, T.A., B. Flanders-Wanner, T.L. Shaffer, R.K. Murphy, and G.A. Knutsen. 2009. An emerging crisis across northern prairie refuges: Prevalence of invasive plants and a plan for adaptive management. *Ecological Restoration* 27:58-65.
- Haferkamp, M.R., R.K. Heitschmidt, and M.G. Karl. 1997. Influence of Japanese brome on western wheatgrass yield. *Journal of Range Management* 50:44-50.
- Hansen, P.L., et al. 1995. Classification and management of Montana's riparian and wetland sites. University of Montana, Montana Forest and Conservation Experiment Station, Miscellaneous Publication No. 54.
- Harmony, K.R. 2007. Grazing and burning Japanese brome (*Bromus japonicus*) on mixed grass rangelands. *Rangeland Ecology and Management* 60:479-486.
- Hart, M., S.S. Waller, S.R. Lowry, and R.N. Gates. 1985. Disking and seeding effects on sod bound mixed prairie. *Journal of Range Management* 38:121-125.
- Hauser, A. S., 2007. *Symphoricarpos occidentalis*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/shrub/arttriw/all.html> accessed (3/23/2017).
- Heidel, B., S.V. Cooper, and C. Jean. 2000. Plant species of special concern and plant associations of Sheridan County, Montana. Report to U.S. Fish and Wildlife Service. Montana Natural Heritage Program, Helena, MT.
- Heidinga, L., and S.D. Wilson. 2002. The impact of an invading alien grass (*Agropyron cristatum*) on species turnover in native prairie. *Diversity and Distributions* 8:249-258.
- Heitschmidt, R.K., and L.T. Vermeire. 2005. An ecological and economic risk avoidance drought management decision support system. In: J.A. Milne (ed.) *Pastoral Systems in Marginal Environments*, XXth International Grasslands Congress, July 2005, p. 178.
- Henderson, A.E., and S.K. Davis. 2014. Rangeland health assessment: A useful tool for linking range management and grassland bird conservation? *Rangeland Ecology and Management* 67:88-98.
- Henderson, D.C., and M.A. Naeth. 2005. Multi-scale impacts of crested wheatgrass invasion in mixed-grass prairie. *Biological Invasions* 7:639-650.
- Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2009. Monitoring manual for grassland, shrubland and savanna ecosystems. U.S. Department of Agriculture, Agricultural Research Service, Jornada Experimental Range, Las Cruces, NM.
- Higgins, K.F. 1986. Interpretation and compendium of historical fire accounts in the Northern Great Plains. U.S. Fish and Wildlife Service Resource Publication 161.
- Holechek, J.L. 1981. Crested wheatgrass. *Rangelands* 3:151-153.
- Howard, J.L. 1999. *Artemisia tridentata* subsp. *wyomingensis*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/shrub/arttriw/all.html> accessed (8/11/2016).
- Joern, A. 2005. Disturbance by fire frequency and bison grazing modulate grasshopper assemblages in tallgrass prairie. *Ecology* 86:861-873.
- Johnson, K. A. 2000. *Prunus virginiana*. In: Fire Effects Information System, U.S. Department of Agriculture, Forest Service <http://www.fs.fed.us/database/feis/plants/tree/pruvir/all.html> accessed (3/23/2017).

- Jones, W.M. 2004. Using vegetation to assess wetland condition: a multimetric approach for temporarily and seasonally flooded depressional wetlands and herbaceous-dominated intermittent and ephemeral riverine wetlands in the northwestern glaciated plains ecoregion, Montana. Report to the Montana Department of Environmental Quality and the U.S. Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT.
- Knopf, F.L. 1996. Prairie legacies—birds. In: F.B. Samson and F.L. Knopf (eds.) *Prairie Conservation: Preserving North America's Most Endangered Ecosystem*, Island Press, Washington, DC, pp. 135-148.
- Knopf, F.L., and F.B. Samson. 1997. Conservation of grassland vertebrates. In: F.B. Samson and F.L. Knopf (eds.) *Ecology and Conservation of Great Plains Vertebrates: Ecological Studies 125*, Springer-Verlag, New York, NY, pp. 273-289.
- Krzic, M., K. Broersma, D.J. Thompson, and A.A. Bomke. 2000. Soil properties and species diversity of grazed crested wheatgrass and native rangelands. *Journal of Range Management* 53:353-358.
- Lacey, J., R. Carlstrom, and K. Williams. 1995. Chiseling rangeland in Montana. *Rangelands* 17:164-166.
- Lauenroth, W.K., O.E. Sala, D.P. Coffin, and T.B. Kirchner. 1994. The importance of soil water in recruitment of *Bouteloua gracilis* in the shortgrass steppe. *Ecological Applications* 4:741-749.
- Laycock, W.A. 1988. History of grassland plowing and grass planting on the Great Plains. In: J.E. Mitchell (ed.) *Impacts of the Conservation Reserve Program in the Great Plains—Symposium Proceedings, September 16-18, 1987*. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.
- Laycock, W.A. 1991. Stable states and thresholds of range condition on North American rangelands. *Journal of Range Management* 44:427-433.
- Lesica, P., and P. Husby. 2006. *Field Guide to Montana's Wetland Vascular Plants*. Montana Wetlands Trust. Helena, MT.
- Lesica, P., and T.H. DeLuca. 1996. Long-term harmful effects of crested wheatgrass on Great Plains grassland ecosystems. *Journal of Soil and Water Conservation* 51:408-409.
- Lockwood, J.A. 2004. *Locust: The devastating rise and mysterious disappearance of the insect that shaped the American frontier*. Basic Books, New York, NY.
- Looman, J., and D.H. Heinrichs. 1973. Stability of crested wheatgrass pastures under long-term pasture use. *Canadian Journal of Plant Science* 53:501-506.
- Lorenzo, A.B., and L.M. Moore. 2006. Plant Guide for Black Hawthorn (*Crataegus douglasii*). USDA Natural Resources Conservation Service [https://plants.usda.gov/plantguide/pdf/pg\\_crdo2.pdf](https://plants.usda.gov/plantguide/pdf/pg_crdo2.pdf) accessed (3/23/2017).
- Madden, E.M., R.K. Murphy, A.J. Hansen, and L. Murray. 2000. Models for guiding management of prairie bird habitat in northwestern North Dakota. *American Midland Naturalist* 144:377-392.
- McNab, W.H., et al. 2007. Description of ecological subregions: Sections of the conterminous United States [CD-ROM]. USDA Forest Service, General Technical Report WO-76B.
- McIntyre, C., K. Newlon, L. Vance, and M. Burns. 2011. Milk, Marias, and St. Mary monitoring: developing a long-term rotating basin wetland assessment and monitoring strategy for Montana. Report to the United States Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT.
- Miller, J.J., and J.A. Brierley. 2011. Solonchetsic soils of Canada: Genesis, distribution, and classification. *Canadian Journal of Soil Science* 91:889-902.
- Montana State College. 1949. Similar vegetative rangeland types in Montana. Montana State College, Agricultural

Experiment Station.

Mushet, D.M., N.H. Euliss, Jr., and C.A. Stockwell. 2012. A conceptual model to facilitate amphibian conservation in the Northern Great Plains. *Great Plains Research* 22:45-58.

Nesser, J.A., G.L. Ford, C.L. Maynard, and D.S. Page-Dumroese. 1997. Ecological units of the Northern Region: Subsections. USDA Forest Service, Intermountain Research Station, General Technical Report INT-GTR-369.

Oard, M.J. 1993. A method of predicting chinook winds east of the Montana Rockies. *Weather and Forecasting* 8:166-180.

Ogle, S.M., W.A. Reiners, and K.G. Gerow. 2003. Impacts of exotic annual brome grasses (*Bromus* spp.) on ecosystem properties of the northern mixed grass prairie. *American Midland Naturalist* 149:46-58.

Roath, L.R. 1988. Implications of land conversions and management for the future. In: J.E. Mitchell (ed.) *Impacts of the Conservation Reserve Program in the Great Plains—Symposium Proceedings, September 16-18, 1987*. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.

Rogler, G.A., and R.J. Lorenz. 1983. Crested wheatgrass: Early history in the United States. *Journal of Range Management* 36:91-93.

Romo, J.T. 2011. Clubmoss, precipitation, and microsite effects on emergence of graminoid and forb seedlings in the semiarid northern mixed prairie of North America. *Journal of Arid Environments* 75:98-105.

Rowe, J.S. 1969. Lightning fires in Saskatchewan grassland. *Canadian Field Naturalist* 83:317-327.

Salo, E.D., et al. 2004. Grazing intensity effects on vegetation, livestock and non-game birds in North Dakota mixed-grass prairie. *Proceedings of the 19th North American Prairie Conference, Madison, WI*.

Samuel, M.J., and R.H. Hart. 1994. Sixty-one years of secondary succession on rangelands of the Wyoming High Plains. *Journal of Range Management* 47:184-191.

Semlitsch, R.D. 2000. Principles for management of aquatic-breeding amphibians. *Journal of Wildlife Management* 64:615-631.

Shay, J., D. Kunec, and B. Dyck. 2001. Short-term effects of fire frequency on vegetation composition and biomass in mixed prairie in south-western Manitoba. *Plant Ecology* 155:157-167.

Smith, B., and G.J. McDermid. 2014. Examination of fire-related succession within the dry mixed-grass subregion of Alberta with the use of MODIS and Landsat. *Rangeland Ecology and Management* 67:307-317.

Smith, R.E. 2013. Conserving Montana's sagebrush highway: Long distance migration in sage-grouse. M.S. thesis, University of Montana, Missoula, MT.

Smoliak, S. 1974. Range vegetation and sheep production at three stocking rates on *Stipa-Bouteloua* prairie. *Journal of Range Management* 27:23-26.

Smoliak, S., and J.F. Dormaar. 1985. Productivity of Russian wildrye and crested wheatgrass and their effect on prairie soils. *Journal of Range Management* 38:403-405.

Smoliak, S., J.F. Dormaar, and A. Johnston. 1972. Long-term grazing effects on *Stipa-Bouteloua* prairie soils. *Journal of Range Management* 25:246-250.

Soil Survey Staff. 2014. Keys to soil taxonomy, 12th edition. USDA Natural Resources Conservation Service.

Soller, D.R. 2001. Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains. U.S. Geological Survey Miscellaneous Investigations Series I-1970-E, scale 1:3,500,000.

- Stephens, S.E., J.J. Rotella, M.S. Lindberg, M.L. Taper, and J.K. Ringelman. 2005. Duck nest survival in the Missouri Coteau of North Dakota: Landscape effects at multiple spatial scales. *Ecological Applications* 15:2137-2149.
- Stewart, R.E., and H.A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. No. 92. US Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
- Tiner, R.W. 2003. Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Region 5, Hadley, MA.  
[http://www.fws.gov/northeast/wetlands/pdf/CorrelatingEnhancedNWIDataWetlandFunctionsWatershedAssessments\[1\].pdf](http://www.fws.gov/northeast/wetlands/pdf/CorrelatingEnhancedNWIDataWetlandFunctionsWatershedAssessments[1].pdf).
- Toledo, D., M. Sanderson, K. Spaeth, J. Hendrickson, and J. Printz. 2014. Extent of Kentucky bluegrass and its effect on native plant species diversity and ecosystem services in the Northern Great Plains of the United States. *Invasive Plant Science and Management* 7:543-552.
- Umbanhowar, Jr., C.E. 2004. Interactions of climate and fire at two sites in the Northern Great Plains. *Palaeogeography, Palaeoclimatology, and Palaeoecology* 208:141-152.
- U.S. Department of Agriculture, Natural Resources Conservation Service. Glossary of landform and geologic terms. National Soil Survey Handbook, Title 430-VI, Part 629.02c.  
[http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2\\_054242](http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242) (Accessed 13 April 2016).
- U.S. Fish and Wildlife Service. 2013. Greater sage-grouse (*Centrocercus urophasianus*) conservation objectives: Final report.
- Vance, L., S. Owen, and J. Horton. 2013. Literature review: Hydrology-ecology relationships in Montana prairie wetlands and intermittent/ephemeral streams. Report to the Cadmus Group and the U.S. Environmental Protection Agency. Montana Natural Heritage Program, Helena, MT.
- Van Dyne, G.M., and W.G. Vogel. 1967. Relation of *Selaginella densa* to site, grazing, and climate. *Ecology* 48:438-444.
- Vaness, B.M., and S.D. Wilson. 2007. Impact and management of crested wheatgrass (*Agropyron cristatum*) in the northern Great Plains. *Canadian Journal of Plant Science* 87:1023-1028.
- Vermeire, L.T., J.L. Crowder, and D.B. Wester. 2011. Plant community and soil environment response to summer fire in the northern Great Plains. *Rangeland Ecology & Management* 64:37-46.
- Vermeire, L.T., J.L. Crowder, and D.B. Wester. 2014. Semiarid rangeland is resilient to summer fire and postfire grazing utilization. *Rangeland Ecology & Management* 67:52-60.
- Vuke, S.M., K.W. Porter, J.D. Lonn, and D.A. Lopez. 2007. Geologic map of Montana - information booklet: Montana Bureau of Mines and Geology Geologic Map 62-D.
- Wambolt, C.L., K.S. Walhof, and M.R. Frisina. 2001. Recovery of big sagebrush communities after burning in southwestern Montana. *Journal of Environmental Management*. 61:243-252
- Watts, M.J., and C.L. Wambolt. 1996. Long-term recovery of Wyoming big sagebrush after four treatments. *Journal of Environmental Management* 46:95-102.
- Whisenant, S.G. 1990. Postfire population dynamics of *Bromus japonicus*. *American Midland Naturalist* 123:301-308.
- Wilson, S.D., and J.M. Shay. 1990. Competition, fire, and nutrients in a mixed-grass prairie. *Ecology* 71:1959-1967.



With, K.A. 2010. McCown's longspur (*Rhynchophanes mccownii*). In: A. Poole (ed.) *The Birds of North America* (online), Cornell Lab of Ornithology, Ithaca. <http://bna.birds.cornell.edu/bna/species/09>.

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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:**
-