

## **Ecological site R058AY737MT Saline Subirrigated 10-19**

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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): 058A–Northern Rolling High Plains, Northern Part

MLRA 058A, Northern Rolling High Plains (Northern Part), is an expansive and agriculturally and ecologically significant area encompassing 26 counties in southeast Montana (99 percent) and northeast Wyoming (1 percent). It stretches approximately 290 miles from east to west and 220 miles from north to south and comprises approximately 42,350 square miles (26,875,928 acres). The area is within the Missouri Plateau, Unglaciaded, Section of the Great Plains Province of the Interior Plains. It is an area of old plateaus and terraces that have been eroded. Slopes generally are gently rolling to steep, and wide belts of steeply sloping badlands border a few of the larger river valleys. In some areas flat-topped, steep-sided buttes rise sharply above the general level of the plains. Elevations generally range from 2,950 to 3,280 feet, increasing from east to west and from north to south.

Tertiary continental shale, siltstone, and sandstone of the Fort Union Formation underlie the eastern one-third to one-half of this area. Marine and continental sediments of the Cretaceous Montana Group underlie the rest of the MLRA, generally at the higher elevations. There are also younger Cretaceous sediments of the Livingston Group occurring between the higher elevation Montana Group sediments and the lower elevation Tertiary sediments. The dominant soil orders in MLRA 058A are Entisols and Inceptisols. The soils in the area dominantly have a frigid soil temperature regime, an ustic soil moisture regime, and mixed or smectitic mineralogy. They range from shallow to very deep and are generally well drained and clayey or loamy.

The area primarily supports native prairie vegetation characterized by a variety of cool-season and warm-season graminoids, forbs, and shrubs. In the western portion of the area, cool-season grasses such as western wheatgrass and bluebunch wheatgrass are dominant but, in the eastern portion of the area, warm-season grasses such as little bluestem and sideoats grama become dominant. Wyoming big sagebrush, silver sagebrush, and fringed sagewort are common shrub species throughout the area. Forested areas occur in rough hilly areas and river breaks, particularly in areas with higher precipitation. Common tree species are ponderosa pine and Rocky Mountain juniper with scattered pockets of Douglas fir.

More than 75 percent of this MLRA is native rangeland utilized for livestock production and more than 50 percent of the MLRA consists of privately-owned ranches. Approximately 15 percent of the MLRA is used as cropland. Other land uses including forestland, urban development, water, and other uses combine for less than 10 percent of the total land use.

### **Classification relationships**

NRCS Soil Geography Hierarchy

- Land Resource Region: Western Great Plains
- Major Land Resource Area (MLRA): 058A Northern Rolling High Plains, Northern Part

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: North Central Highlands (331K) and Powder River Basin (331G)

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: Salt Marsh Formation (2.C.5)
- Division: Distichlis spicata - Hordeum jubatum Great Plains Saline Marsh Division (2.C.5.Na)
- Macrogroup: Great Plains Saline Wet Meadow and Marsh Macrogroup (2.C.5.Na.1)
- Group: Western Great Plains Saline Wet Meadow Group (2.C.5.Na.1.b)

EPA Ecoregions

- Level 1: Great Plains (9)
- Level 2: West-Central Semi-Arid Prairies (9.3)
- Level 3: Northwestern Great Plains (9.3.3)
- Level 4: Montana Central Grasslands (43n), River Breaks (43c), and Pine Scoria Hills (43p)

## Ecological site concept

This ecological site occurs on drainageways, stream terraces, or floodplain steps at elevations ranging from 1,900 to 3,500 feet where salt and/or alkali accumulations are apparent and salt tolerant species dominate the plant community composition. This ecological site can also occur around pond margins, particularly if the water recedes but a permanent water table is maintained. Slopes are generally less than 4 percent. This site occurs on all aspects, although aspect is not a significant factor. The soil textures are typically clay loam but may range from loam to clay or silty clay.

## Associated sites

R058AY723MT	<b>Wet Meadow 10-19</b> The Wet Meadow ecological site is found adjacent to the Saline Subirrigated ecological site, usually in depressions or concave areas where flooding is very frequent and a water table is shallow and persistent.
R058AY713MT	<b>Saline Overflow 10-14</b> Saline Overflow ecological site is found adjacent to the Saline Subirrigated ecological site, usually on higher terraces where groundwater is farther from the surface.

## Similar sites

R058AY723MT	<b>Wet Meadow 10-19</b> This site differs from the Saline Subirrigated ecological site in that the soils do not contain accumulated salts in the upper 4 inches and the depth to a water table is less than 24 inches.
R058AY738MT	<b>Subirrigated 10-19</b> This site differs from the Saline Subirrigated ecological site in that the soils do not contain accumulated salts in the upper 4 inches Depth to a water table is 24 to 40 inches.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Sarcobatus vermiculatus</i>
Herbaceous	(1) <i>Sporobolus airoides</i> (2) <i>Puccinellia nuttalliana</i>

## Physiographic features

This ecological site occurs on drainageways, stream terraces, or floodplain steps. The slopes are generally less than four percent. This site occurs on all aspects. Aspect is not a significant factor.

**Table 2. Representative physiographic features**

Landforms	(1) Drainageway (2) Stream terrace (3) Flood-plain step
Flooding frequency	None to rare
Ponding frequency	None
Elevation	1,900–3,500 ft
Slope	0–4%
Water table depth	24–40 in
Aspect	Aspect is not a significant factor

## Climatic features

MLRA 058A is a semi-arid region and is considered to have a continental climate characterized by cold winters, hot summers, low humidity, light rainfall, and much sunshine. The climate is the result of the MLRA's location in the geographic center of North America. Temperatures can be extreme. The average annual temperature is 41 to 49 degrees Fahrenheit. Summer daytime temperatures are typically quite warm, generally averaging in the lower to mid 80 degree range for July and August. Summertime temperatures will typically reach 100 degrees or more at some point during the summer and can reach 90 degrees during any month between May and September. Conversely, winter temperatures can be cold, averaging in the lower teens or less for December and January. There will typically be several days of below zero temperatures each winter. It is not uncommon for temperatures to reach 30 to 40 degrees below zero, or even colder, most any winter.

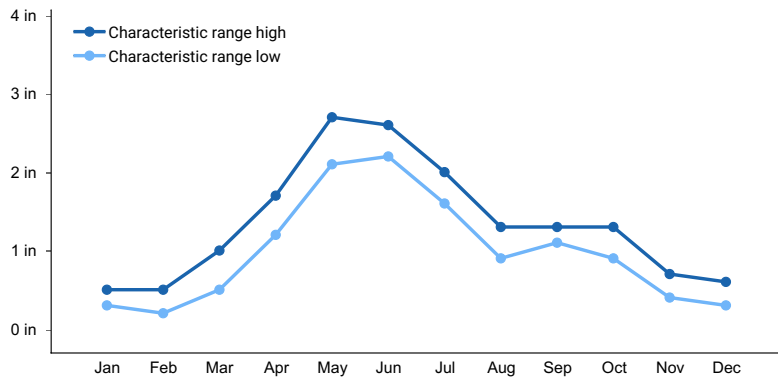
During an average year, 70 to 75 percent of the annual precipitation falls between April and September, which are the primary growing season months. Most of the rainfall occurs as frontal storms early in the growing season during the months of May and June. Some high-intensity, convective thunderstorms occur in July and August, and some rainfall occurs in autumn. Later summer precipitation is greater in the eastern portion of the MLRA, which effects plant community composition. Winter precipitation occurs as snow although snowfall is not heavy, averaging about 39 inches annually, and snow cover is typically 1 to 3 inches. Heavy snowfall occurs infrequently, usually late in the winter or early spring. The average annual precipitation ranges from 8 to 22 inches but is typically 10 to 19 inches throughout most of the area. Precipitation fluctuates widely from year to year and severe drought occurs 2 out of 10 years on average.

There are few natural barriers on the northern Great Plains and the winds move freely across the plains and account for rapid changes in temperature. Spring can be windy throughout the MLRA, with winds averaging over 10 mph about 15 percent of the time. Speeds of 50 mph or stronger can occasionally occur. During the winter months, the western half of the MLRA 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).

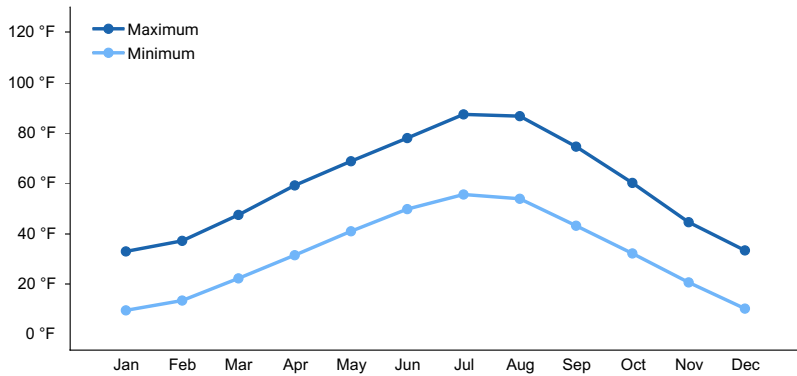
For local climate station information, refer to <https://wrcc.dri.edu/summary/Climsmemt.html>.

**Table 3. Representative climatic features**

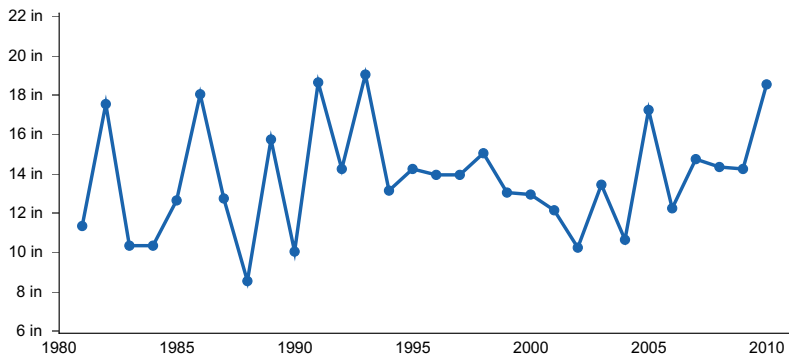
Frost-free period (characteristic range)	70-150 days
Freeze-free period (characteristic range)	90-180 days
Precipitation total (characteristic range)	10-19 in
Frost-free period (average)	121 days
Freeze-free period (average)	143 days
Precipitation total (average)	15 in



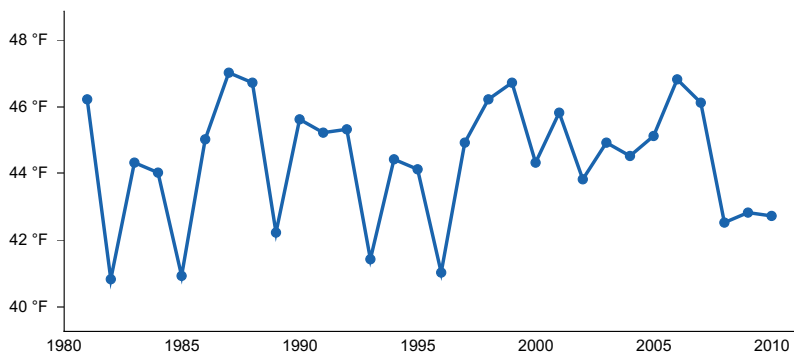
**Figure 1. Monthly precipitation range**



**Figure 2. Monthly average minimum and maximum temperature**



**Figure 3. Annual precipitation pattern**



**Figure 4. Annual average temperature pattern**

## Climate stations used

- (1) RAPELJE [USC00246862], Rapelje, MT
- (2) HYSHAM 25 SSE [USC00244364], Bighorn, MT
- (3) BRANDENBERG [USC00241084], Rosebud, MT

- (4) TERRY 21 NNW [USC00248169], Terry, MT
- (5) BLOOMFIELD 5 NNE [USC00240923], Bloomfield, MT
- (6) GLENDIVE [USC00243581], Glendive, MT
- (7) POWDERVILLE 8 NNE [USC00246691], Volborg, MT
- (8) JORDAN 23 ENE [USC00244530], Jordan, MT
- (9) FT PECK PWR PLT [USC00243176], Fort Peck, MT
- (10) CIRCLE [USC00241758], Circle, MT
- (11) BROCKWAY 3 WSW [USC00241169], Brockway, MT
- (12) MILES CITY F WILEY FLD [USW00024037], Miles City, MT
- (13) MIZPAH 4 NNW [USC00245754], Ismay, MT
- (14) SAND CREEK [USC00247342], Roy, MT
- (15) ROCK SPRINGS [USC00247136], Angela, MT
- (16) COHAGEN [USC00241875], Cohagen, MT
- (17) WINIFRED [USC00249033], Hilger, MT
- (18) COLUMBUS [USC00241938], Columbus, MT
- (19) WYOLA 1 SW [USC00249175], Wyola, MT
- (20) EKALAKA [USC00242689], Ekalaka, MT
- (21) MELSTONE [USC00245596], Musselshell, MT
- (22) YELLOWTAIL DAM [USC00249240], Lodge Grass, MT

## Influencing water features

This is a floodplain or drainageway site that receives additional moisture from groundwater and occasionally stream overflow. When on floodplains, the site may be flooded for brief durations during major flood events. A seasonal groundwater table is present between 24 and 40 inches below the soil surface, particularly during spring.

## Wetland description

Palustrine Emergent (Cowardin et al., 1979)

## Soil features

Soils for this ecological site are typically very deep (greater than 60 inches to bedrock), somewhat poorly drained, and derived from alluvium from sedimentary rock. All soils in this concept are characterized by an accumulation of salts and saline, sodic, or saline-sodic conditions occur within 4 inches of the surface. A seasonal high-water table is present between 24 and 40 inches below the soil surface. Surface horizon textures are typically clay loam but may range from loam to clay or silty clay. Subsurface horizon textures are typically clay loam, loam or silty clay loam and may contain stratified layers of sandy loam, loam, clay loam, silty clay loam, or silt loam. Coarse fragments are typically not present in the upper 20 inches of soil. The soil temperature regime is primarily frigid, with smaller areas of mesic temperature regime present. The soil moisture regime is aridic ustic and typic ustic. The following figure shows a typical soil profile for this ecological site.

Soil Series:	Horizon	Depth	Texture
Thibadeau	A	0-2	Clay loam
	C	2-14	Clay loam
	Cyz	14-60	clay loam consisting of thin layers of loam and fine sand loam

Figure 5. Typical Soil Profile

**Table 4. Representative soil features**

Parent material	(1) Alluvium–sedimentary rock
Surface texture	(1) Clay loam (2) Loam (3) Silty clay loam (4) Clay (5) Silty clay
Drainage class	Somewhat poorly drained
Permeability class	Moderately slow
Soil depth	60–72 in
Surface fragment cover ≤3"	0–3%
Surface fragment cover >3"	0–2%
Available water capacity (0-20in)	2–2.2 in
Calcium carbonate equivalent (0-20in)	1–5%
Electrical conductivity (0-20in)	8–16 mmhos/cm
Sodium adsorption ratio (0-20in)	8–20
Soil reaction (1:1 water) (0-20in)	7.4–9.6
Subsurface fragment volume ≤3" (0-20in)	0%
Subsurface fragment volume >3" (0-20in)	0%

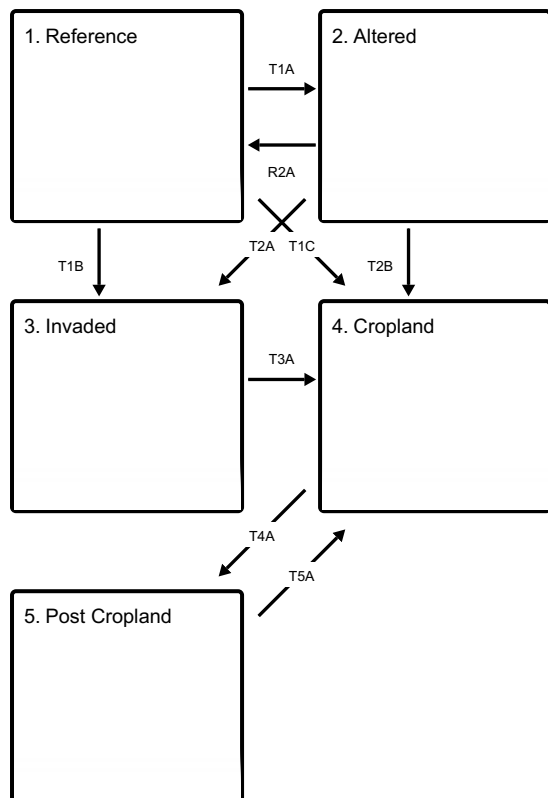
## Ecological dynamics

Interpretations are primarily based on the Reference state, which is used as a reference in order to understand the original potential of the site. This ecological site developed under the combined influences of climatic conditions, periodic fire activity, grazing by large herbivores, and impacts from small mammals and insects. Changes may occur to the Reference state due to management actions such as improper grazing management, climatic conditions such as drought, and natural events such as multiple fires in close succession. The reference state for this ecological site is dominated by a diversity of medium height, cool-season and warm-season grasses, which are tightly intermixed and well distributed over the site. Various forbs, and shrubs are common on this site. The Reference state is not necessarily the management goal, as other vegetative states may be considered desired plant communities as long as critical resource concerns are met.

In addition to the Reference state, other plant communities can occur on this site and are usually the result of historic management practices. Long term overgrazing on this ecological site results in a decrease of mid-grasses and more palatable forbs and in an increase of shortgrasses, sedges, and less palatable forbs. The absence of prescribed fire and wildfire favors half-shrubs and shrubs while more frequent fire intervals favor herbaceous species. There are various transitional stages which may occur on this ecological site.

## State and transition model

## Ecosystem states



**T1A** - Prolonged drought, improper grazing, or a combination of these factors

**T1B** - Introduction of invasive species (non-native perennial grasses, noxious weeds, etc.)

**T1C** - Tillage or herbicide application and seeding of annual crops or non-native hayland

**R2A** - Proper grazing management in combination with rangeland seeding, grazing land mechanical treatment, and timely moisture (management intensive and costly).

**T2A** - Introduction of non-native invasive species (non-native perennial grasses, noxious weeds, etc.)

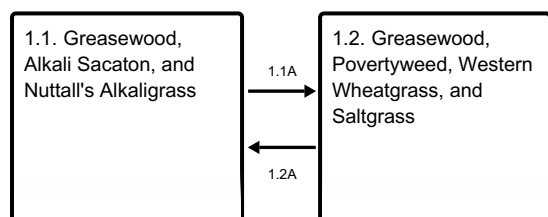
**T2B** - Tillage or herbicide application and seeding of annual crops or non-native hayland

**T3A** - Tillage or herbicide application and seeding of annual crops or non-native hayland

**T4A** - Cessation of annual cropping

**T5A** - Tillage or herbicide application and seeding of annual crops or non-native hayland

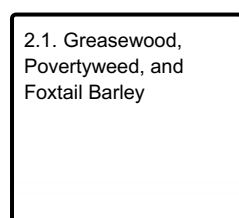
## State 1 submodel, plant communities



**1.1A** - Drought, improper grazing management

**1.2A** - Normal or above average precipitation, proper grazing management

## State 2 submodel, plant communities



### State 3 submodel, plant communities

3.1. Invaded

### State 4 submodel, plant communities

4.1. Cropland

### State 5 submodel, plant communities

5.1. Abandoned  
Cropland

5.2. Perennial Grass

## State 1 Reference

The Reference state evolved under the combined influences of climatic conditions, periodic fire activity, grazing by large herbivores, and impacts from small mammals and insects. The Reference State is the plant community in which interpretations are primarily based and is used as a reference in order to understand the original potential of the site. The Reference state for this ecological site consists of two communities.

### Dominant plant species

- greasewood (*Sarcobatus vermiculatus*), shrub
- alkali sacaton (*Sporobolus airoides*), grass
- Nuttall's alkaligrass (*Puccinellia nuttalliana*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- saltgrass (*Distichlis spicata*), grass

### Community 1.1 Greasewood, Alkali Sacaton, and Nuttall's Alkaligrass

This plant community is characterized by a plant community comprised of sodium-tolerant bunchgrasses such as alkali sacaton, alkali cordgrass, and Nuttall's alkaligrass. Shortgrasses and sedges such as inland saltgrass, alkali bluegrass, Sandberg bluegrass, and clustered field sedge are present at low canopy cover. Forbs such as poverty sumpweed, Pursh seepweed, American licorice, and aster occur at approximately 10 percent canopy cover. Shrubs such as Gardner's saltbush, greasewood, and silver buffaloberry occur at approximately 5 percent canopy cover.

### Community 1.2 Greasewood, Povertyweed, Western Wheatgrass, and Saltgrass

This plant community is characterized by a rhizomatous wheatgrass community including species such as western wheatgrass. Sodium-tolerant bunchgrasses such as alkali sacaton, alkali cordgrass, and Nuttall's alkaligrass are rare. Shortgrasses and sedges such as saltgrass, alkali bluegrass, Sandberg bluegrass, and clustered field sedge are common. Unpalatable forbs and foxtail barley are increasing. Shrubs such as Gardner's saltbush, greasewood, and silver buffaloberry occur at approximately 5 percent canopy cover.



## **Pathway 1.1A**

### **Community 1.1 to 1.2**

Drought, improper grazing management such as continuous season-long or year-long grazing, or a combination of these factors can shift community 1.1 to community 1.2.

## **Pathway 1.2A**

### **Community 1.2 to 1.1**

Normal or above-average precipitation and proper grazing management shifts community 1.2 to community 1.1.

## **State 2**

### **Altered**

The dynamics of the Altered state are driven by long-term drought, improper grazing management such as continuous season-long or year-long grazing, or a combination of these factors. The Altered state for this ecological site consists of one community.

#### **Dominant plant species**

- greasewood (*Sarcobatus vermiculatus*), shrub
- foxtail barley (*Hordeum jubatum*), grass
- povertyweed (*Iva axillaris*), other herbaceous

### **Community 2.1**

#### **Greasewood, Povertyweed, and Foxtail Barley**

This plant community is characterized by a dominance of foxtail barley and unpalatable forbs such as povertyweed, Pursh seepweed, American licorice, and aster. Mid-statured grasses such as alkali sacaton, alkali cordgrass, Nuttall's alkaligrass, and western wheatgrass and palatable shrubs are rare. Shrubs occur at approximately 5 percent canopy cover.

## **State 3**

### **Invaded**

The Invaded state occurs when invasive plant species invade native plant communities and displace the native species. The Invaded state consists of one community.

#### **Dominant plant species**

- cheatgrass (*Bromus tectorum*), grass
- field brome (*Bromus arvensis*), grass

### **Community 3.1**

#### **Invaded**

Observations suggest that native species diversity declines significantly when invasive or noxious species exceed approximately 30 percent of the plant community. Non-native, perennial, drought tolerant grasses such as crested wheatgrass, non-native, annual, invasive species such as cheatgrass and field brome, and noxious weed species can eventually dominate the seedbank of this site and displace native species. Reduced plant species diversity, simplified structural complexity, and altered ecological processes result in a state that is substantially departed from the Reference state.

## **State 4**

### **Cropland**

The Cropland state occurs when cultivation occurs to the land. The Cropland state consists of one community.

## **Community 4.1**

### **Cropland**

The land is cultivated and converted to crop production. Typically, the site is planted to non-native perennial hay. Occasionally, cereal grains such as wheat, and barley are attempted, but this site is poorly suited to such crops and cereal grain production is generally unsuccessful. Cultivation is frequently accompanied by irrigation practices resulting in vastly altered vegetation, soil morphology, and hydrology on the site.

## **State 5**

### **Post Cropland**

The Post Cropland state occurs when cultivated cropland is abandoned and allowed to either re-vegetate naturally or is seeded back to perennial species for livestock grazing or wildlife use. This state can transition back to the Cropland state if the site is returned to cultivation. The Post Cropland state has two communities.

## **Community 5.1**

### **Abandoned Cropland**

In the absence of active management, the site can re-vegetate naturally and potentially return to a perennial grassland community over time. Shortly after cropland is abandoned, annual and biennial forbs and annual brome grasses invade the site. The site is highly susceptible to erosion due to the absence of perennial species. Eventually, these pioneering annual species are replaced by perennial forbs and perennial shortgrasses. Depending on the historical management of the site, mid-statured perennial grasses may also return; however, species composition will depend upon the seed bank. Invasion of the site by exotic species, such as crested wheatgrass and annual bromes, will depend upon the site's proximity to a seed source. Fifty or more years after cultivation, these sites may have species composition similar to communities in the Reference state. However, soil quality is consistently lower than conditions prior to cultivation and a shift to the Reference state is unlikely within a reasonable timeframe (Dormaer, J.F., and S. Smoliak. 1985).

## **Community 5.2**

### **Perennial Grass**

When the site is seeded to perennial forage species this community can persist for several decades. Introduced perennial grasses, in particular, may form monocultures that persist for 60 years or more (Samuel, M.J., and R.H. Hart. 1994). A mixture of native species may also be seeded to provide species composition and structural complexity similar to that of the Reference state. However, soil quality and morphology have been substantially altered and will not return to pre-cultivation conditions within a reasonable timeframe.

## **Transition T1A**

### **State 1 to 2**

Prolonged drought, improper grazing management such as continuous season-long or year-long grazing, or a combination of these factors weaken the resilience of the Reference state and drive its transition to the Altered state. The Reference state transitions to the Altered state when mid-statured graminoids become rare and unpalatable species such as foxtail barley and poverty sumpweed, dominate the plant community.

## **Transition T1B**

### **State 1 to 3**

The Reference state transitions to the Invaded state when non-native grasses or noxious weeds invade the plant community. Exotic plant species dominate the site in terms of cover and production and site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference state.

## **Transition T1C**

### **State 1 to 4**

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and

barley, transitions the Reference state to the Cropland state.

## **Restoration pathway R2A**

### **State 2 to 1**

Proper grazing management in combination with normal or above-normal moisture, and revegetation transition the Altered state back to the Reference state. These practices are typically management intensive and costly, therefore, returning the Altered state to the Reference state can require considerable cost, energy, and time.

### **Conservation practices**

Prescribed Grazing
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## **Transition T2A**

### **State 2 to 3**

The Altered state transitions to the Invaded state when non-native grasses or noxious weeds invade the plant community. Exotic plant species dominate the site in terms of cover and production and site resilience has been substantially reduced. In addition, other rangeland health attributes, such as reproductive capacity of native grasses and soil quality, have been substantially altered from the Reference state.

## **Transition T2B**

### **State 2 to 4**

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Altered state to the Cropland state.

## **Transition T3A**

### **State 3 to 4**

The Invaded state will transition to the Cropland state when the site is placed under cultivation.

## **Transition T4A**

### **State 4 to 5**

The transition from the Cropland state to the Post Cropland state occurs with the cessation of cultivation. The site may also be seeded to introduced perennial forage species or a mix of native species.

## **Transition T5A**

### **State 5 to 4**

Tillage or application of herbicide followed by seeding of cultivated crops, such as winter wheat, spring wheat, and barley, transitions the Post Cropland state to the Cropland state.

## **Additional community tables**

### **Inventory data references**

Specific field data was not obtained for this provisional ecological site description. Existing field data were used in conjunction with a review of the scientific literature and professional experience to approximate the plant communities, states, and transitions. All community phases are considered provisional based on the sources identified in this ecological site description.

### **Other references**

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.
- 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.
- 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.
- 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.
- 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.
- DeLuca, T.H., and P. Lesica. 1996. Long-term harmful effects of crested wheatgrass on Great Plains grassland ecosystems. *Journal of Soil and Water Conservation* 51:408-409.
- 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.
- 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.

Federal Geographic Data Committee. 2008. The National Vegetation Classification Standard, Version 2. FGDC Vegetation Subcommittee. FGDC-STD-005-2008 (Version 2). pp. 126.

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.

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.

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.

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).

Interagency Ecological Site Handbook for Rangelands. USDA Natural Resources Conservation Service, USDA Forest Service, USDI Bureau of Land Management. January 2013.

Joern, A. 2005. Disturbance by fire frequency and bison grazing modulate grasshopper assemblages in tallgrass prairie. *Ecology* 86:861-873.

Lacey, J., R. Carlstrom, and K. Williams. 1995. Chiseling rangeland in Montana. *Rangelands* 17:164-166.

Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. USDA Handbook 296. USDA Natural Resources Conservation Service. 2006.

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.

Lockwood, J.A. 2004. *Locust: The devastating rise and mysterious disappearance of the insect that shaped the American frontier*. Basic Books, New York, NY.

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.

Montana State College. 1949. Similar vegetative rangeland types in Montana. Montana State College, Agricultural

Experiment Station.

National Ecological Site Handbook. USDA Natural Resources Conservation Service. March 2017.

National Range and Pasture Handbook. USDA Natural Resources Conservation Service. December 2003.

National Soil Information System. USDA Natural Resources Conservation Service.  
[https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2\\_053552](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053552).

National Soil Survey Handbook. USDA Natural Resources Conservation Service. November 2019.

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.

NRCS Plants Database. USDA Natural Resources Conservation Service. <https://plants.usda.gov/java/>.

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.

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.

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., 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 Manual. USDA Natural Resources Conservation Service. March 2017.

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

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.

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 and 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 and 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.

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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	05/10/2025
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. Number and extent of rills:
-

2. **Presence of water flow patterns:**

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3. **Number and height of erosional pedestals or terracettes:**

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

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5. **Number of gullies and erosion associated with gullies:**

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6. **Extent of wind scoured, blowouts and/or depositional areas:**

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7. **Amount of litter movement (describe size and distance expected to travel):**

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

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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:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**



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14. **Average percent litter cover (%) and depth ( in):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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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:**

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17. **Perennial plant reproductive capability:**

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