

## Ecological site R046XC597MT Saline Lowland (SL) RRU 46-C 15-19 PZ

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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): 046X–Northern and Central Rocky Mountain Foothills

Major Land Resource Area (MLRA) 46, Rocky Mountain Foothills, is approximately 11.6 million acres. MLRA 46's extent has changed over recent years and is now primarily located in Montana and Wyoming with limited acres in Utah and Colorado. It spans from the Canadian border south to the Uinta Mountains of Northwest Colorado. MLRA 46 is a transitional MLRA between the plains and mountains of primarily non-forested rangeland. In Montana, three Land Resource Units (LRUs) exist based on differences in geology, landscape, soils, water resources, and plant communities. Elevations for this MLRA in Montana vary from a low of 3200 to 6500 feet (975 to 1981m) however the elevations on the fringes of this MLRA may fall outside of that range in extremely small isolated areas where the boundaries between neighboring MLRAs are not easily defined. Annual precipitation ranges from 8 inches (254 mm) to, in very isolated areas, 42 inches (1083 mm). In general precipitation rarely exceeds 24 inches (610 mm). Frost-free days are variable from 50 days near the Crazy and Beartooth Mountains to 130 days in the foothills south of the Bear's Paw Mountains of Central Montana. The geology of MLRA 46 is generally Cretaceous and Jurassic marine sediments.

MLRA 46's plant communities are dominated by cool season bunchgrasses with mixed shrubs. This MLRA is rarely forested; however, ponderosa and limber pine do occupy areas. Portions of this MLRA may have a subdominance of warm-season mid-statured bunchgrasses like little bluestem; however, the general concept of the MLRA does not have a large component of warm-season species. Wyoming big sagebrush, mountain big sagebrush, silver sagebrush, common snowberry, and shrubby cinquefoil tend to be the dominant shrub component. The kind and presences of shrubs tends to be driven by a combination of soils and climate. Due to the variable nature of the Land Resources Units, Climatic subsets will be necessary to describe the ecological sites and the variation of plant communities for this MLRA.

### LRU notes

LRU C is generally located in Central Montana. It borders the Little Belt Mountains, Highwood Mountains, Snowy Mountains (Big and Little), Crazy Mountains, and Castle Mountains. Included in this LRU are the foothills of the island mountain groups of the Bear's Paw and Little Rocky Mountains. This LRU borders MLRAs 43B, 52 and 58. LRU C is the second largest of the LRUs located in Montana occupying approximately 2.6 million acres. Cities and towns located in this LRU includes Stanford, Lewistown, Grass Range, and Harlowton. Elevation ranges from 2880 feet (878 m) to 6783 feet (2068 m).

The geology is sedimentary in nature with the majority including the Colorado Shale Formation, Kootenai Formation (mixed sedimentary), Mississippian Formation (carbonatic sedimentary), terrace deposits (alluvium), Tertiary mixed sedimentary. Areas of the Claggett Formation (mudstone), Devonian (carbonatic sedimentary) as well as intrusive and extrusive volcanics (mixed) exist in the foothills of the island mountains. Landforms include hillslopes, drainage ways, fan remnants, valleys, and escarpments.

This LRU is dominated by deep, well drained soils. Soil depth is mixed with 45 percent moderately-deep, 45 percent

very deep, and 10 percent other soil depth. Slopes are most frequently 0 to 15 percent and 15 to 30 percent, while higher sloping areas (30 to 45 percent) exist along the Little Belt and Highwood interfaces. Slightly acid to moderately alkaline soils throughout. Small areas of moderately acid soils exist in places, in particular around Highwoods. Vast differences in soil texture within LRU exist likely due to the variation in parent material.

The climate of this LRU is classic to the MLRA concept. The precipitation falls primarily as rain in the spring however areas may receive high amounts of snowfall (i.e. Lewistown). Precipitation ranges are from 13.7 inches (348 mm) to a rare 37.4 inches (942 mm) with 16 inches as an average. This LRU has an average air temperature of 44 degrees Fahrenheit (6.75 degrees C) with a range of 38 degrees Fahrenheit (3.38 degrees C) to 47.3 degrees Fahrenheit (8.52 degrees C). Frost-free days tends to be one of the longest of the Montana LRUs with a range of 70-130 days. Soil moisture regime is ustic with a frigid soil temperature regime. Due to the variability in climate of this LRU, climatic subsets will be necessary to accurately describe the ecological processes.

Major watersheds within this LRU include Big Spring Creek, Judith River, Swimming Woman Creek, and Musselshell River. These watersheds provide irrigation water for production of small grains and hay. As these watersheds leave the neighboring MLRA 43B, these river systems offer fishing and other recreational opportunities.

Cropland conversion is the largest land conversion within this LRU. Small grains such as wheat and barley are the most common particularly in Judith Basin County. Conversion to recreational property is becoming a more frequent occurrence, particularly near Lewistown.

### Ecological site concept

- Site receives additional effective moisture because of run-in or stream overflow
- Seasonal water table greater than or equal to 40 inches from ground surface
- Soil saline (EC greater than 4 within surface 4 inches)
- Salt tolerant plants dominate site

### Associated sites

R046XC603MT	<b>Saline Upland (SU) RRU 46-C 15-19 PZ</b> Site has similar plant community and is typically located slightly higher on the landscape.
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### Similar sites

R046XC603MT	<b>Saline Upland (SU) RRU 46-C 15-19 PZ</b> Site has similar plant community but produces much less vegetation.
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Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Sarcobatus vermiculatus</i> (2) <i>Krascheninnikovia lanata</i>
Herbaceous	(1) <i>Sporobolus airoides</i> (2) <i>Leymus cinereus</i>

### Physiographic features

This ecological site occurs on overflow lands where salt and/or alkali accumulations are apparent and salt-tolerant species dominate the plant community. It is associated mainly with ephemeral streams (those that flow only in response to a precipitation event or snow melt, and the water table is lower than the channel bottom).

The site is nearly level to gently sloping; rarely exceeding 5 percent slope.

Table 2. Representative physiographic features

Landforms	(1) Foothills > Slough (2) Foothills > Stream terrace (3) Foothills > Fan (4) Foothills > Swale (5) Foothills > Pothole
Flooding duration	Extremely brief (0.1 to 4 hours) to brief (2 to 7 days)
Flooding frequency	None to rare
Elevation	3,600–5,800 ft
Slope	0–5%
Water table depth	40 in
Aspect	Aspect is not a significant factor

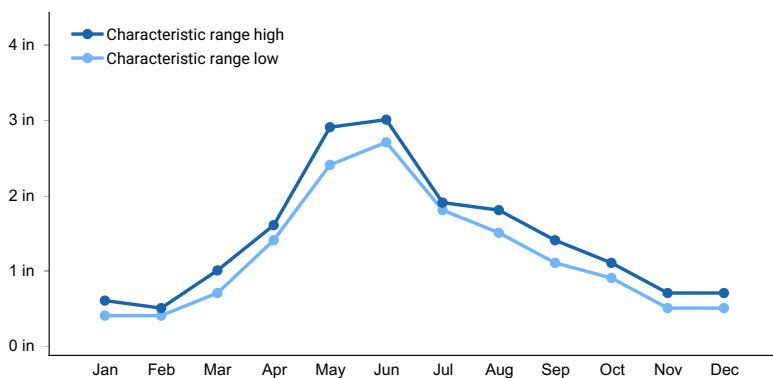
## Climatic features

The climate of the Saline Lowland site falls into Climatic Subset B. The central concept of Climatic Subset B is 15 to 19 inches Relative Effective Annual Precipitation (REAP) and 70 to 130 days frost-free. Calculated averages based on climate stations suggest that this ecological site receives just over 16 inches of precipitation with 76 to 111 frost-free days.

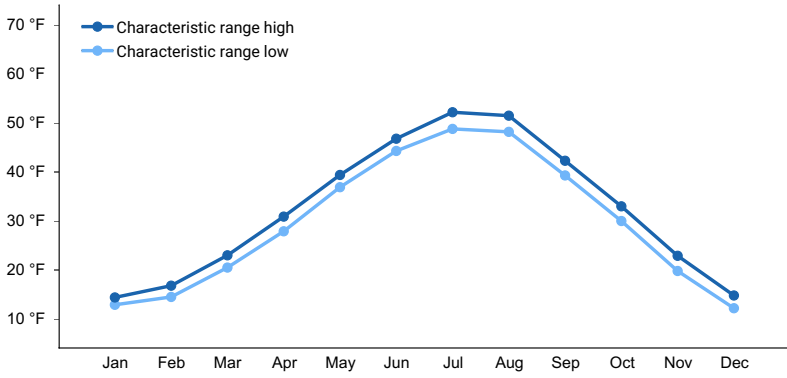
The soil temperature regime for this Saline Lowland Ecological Site is Frigid and the soil moisture regime is Ustic

**Table 3. Representative climatic features**

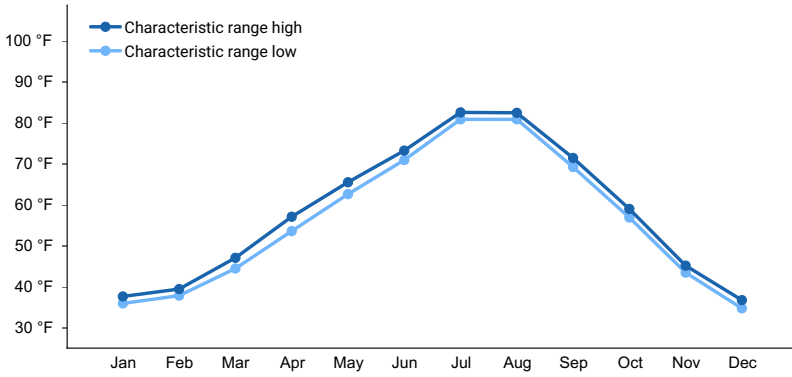
Frost-free period (characteristic range)	49-92 days
Freeze-free period (characteristic range)	101-116 days
Precipitation total (characteristic range)	15-17 in
Frost-free period (actual range)	42-130 days
Freeze-free period (actual range)	70-125 days
Precipitation total (actual range)	15-19 in
Frost-free period (average)	76 days
Freeze-free period (average)	111 days
Precipitation total (average)	16 in



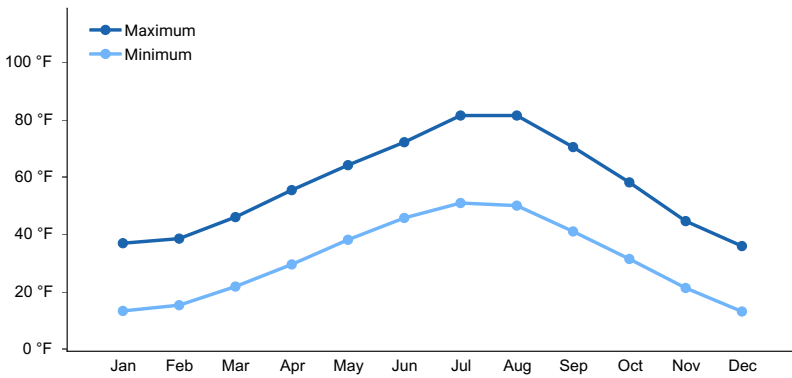
**Figure 1. Monthly precipitation range**



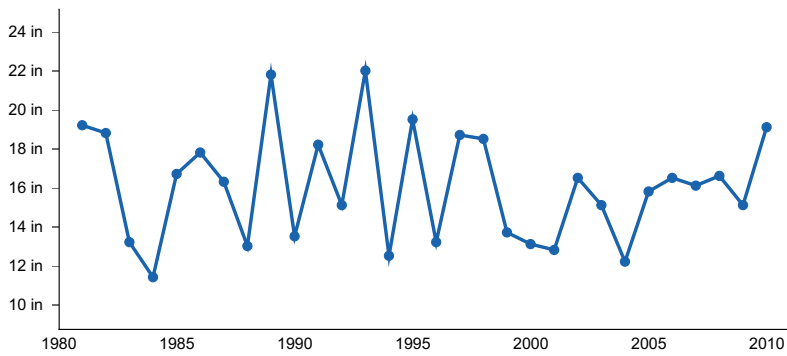
**Figure 2. Monthly minimum temperature range**



**Figure 3. Monthly maximum temperature range**



**Figure 4. Monthly average minimum and maximum temperature**



**Figure 5. Annual precipitation pattern**

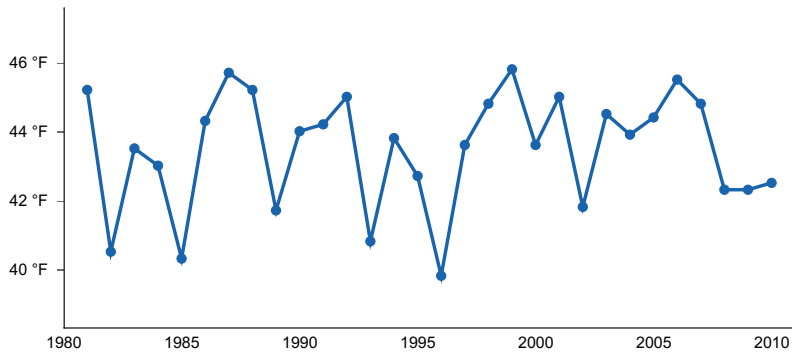


Figure 6. Annual average temperature pattern

### Climate stations used

- (1) JUDITH GAP 13 E [USC00244545], Judith Gap, MT
- (2) HOBSON [USC00244193], Hobson, MT
- (3) MOCCASIN EXP STN [USC00245761], Moccasin, MT
- (4) DENTON [USC00242347], Denton, MT
- (5) STANFORD [USC00247864], Stanford, MT
- (6) LEWISTOWN MUNI AP [USW00024036], Lewistown, MT
- (7) GRASS RANGE [USC00243727], Grass Range, MT

### Influencing water features

Site is located at the bottom third of the slope where run-in or stream overflow brings saline or alkali water to or near the surface where salt accumulate. This site may have a seasonal water table as close as 40 inches from the surface. Seasonal water flows as a result of high precipitation events or spring snowmelt. These areas may also be associated near springs or seeps that travel through salt laden material.

### Wetland description

Site is not considered a wetland

### Soil features

The soils on this site are moderately to strongly saline, medium- to fine-textured, moderately deep to deep, but poorly developed. This site has a seasonal high water table that is deeper than 40 inches. Soils tend to be saline or sodic. Soluble salt accumulations are often apparent at or near the surface. Most herbaceous roots extend less than 20 inches below the soil surface. Surface textures are mainly silty clay, silty clay loam, clay loam and loam. Permeability varies with surface texture and the amount of salt and/or sodium present. Soil ph varies from 7.4 – 9.0.

Table 4. Representative soil features

Parent material	(1) Alluvium–sedimentary rock
Surface texture	(1) Clay loam (2) Loam (3) Silty clay loam (4) Silty clay
Family particle size	(1) Fine (2) Fine-loamy
Drainage class	Moderately well drained to somewhat poorly drained
Permeability class	Moderately slow to very slow
Electrical conductivity (0-40in)	4–16 mmhos/cm

Sodium adsorption ratio (0-40in)	5-25
Soil reaction (1:1 water) (0-40in)	7.4-9

**Table 5. Representative soil features (actual values)**

Drainage class	Not specified
Permeability class	Not specified
Electrical conductivity (0-40in)	Not specified
Sodium adsorption ratio (0-40in)	3-35
Soil reaction (1:1 water) (0-40in)	Not specified

## Ecological dynamics

The Saline Lowland (SL) Ecological Site is characterized by the production and composition of the Reference Plant Community, which is defined by soils, precipitation, and the temperature regime influencing the site. The Saline Lowland ecological site receives

additional effective moisture from offsite runoff from precipitation events or stream overflow. The site has saline or saline-sodic conditions within 4 inches of the soil surface which is expressed as an Electrical Conductivity of 4-30 mmhos/cm. This site may also have a seasonal water table within 40 inches of the soil surface.

In the Rocky Mountain Foothills of Central Montana, MLRA 46X LRU B is found where an Ustic soil moisture regime occurs. This area is typified by a frigid soil temperature phase which receives a yearly representative value of 15 to 19 inches of relative effective annual precipitation and between 70 and 110 consecutive frost-free days annually.

Much of the precipitation comes in May and June. Primary plant growth typically occurs between May and early July however due to the increased soil moisture the growing season is extended longer into the summer than other sites in this MLRA. Dominant plants are those that have adapted to these conditions. A period of fall "green-up" can occur amongst this cool season dominated plant community if adequate precipitation is present.

The reference plant community is dominated by alkali sacaton (*Sporobolus airoides*), basin wildrye (*Leymus cinereus*), western wheatgrass (*Pascopyrum smithii*), alkali cordgrass (*Spartina gracilis*), and Sandberg bluegrass (*Poa secunda*). Subdominant species may include black greasewood (*Sarcobatus vermiculatus*), big sagebrush (*Artemisia tridentata*), winterfat (*Krascheninnikovia lanata*) and Gardner's saltbush (*Atriplex gardnerii*).

As the community changes away from reference, cool season shortgrasses tend to increase. If allowed to continue non-native grasses (cheatgrass, field brome, and ventenata) tend to take over the site. Throughout this time bare ground increases exponentially. The short rooted nature of the sodforming grasses erosion can occur rapidly.

Historical records indicate, prior to the introduction of livestock (cattle and sheep) during the late 1800's, elk and bison grazed this ecological site. Due to the nomadic nature and herd structure of bison, areas that were grazed received periodic high intensity short duration grazing pressure.

Livestock grazing has occurred on most of this ecological site for more than 150 years. The gold boom in the 1860s brought the first herds of livestock overland from Texas, and homesteaders began settling the area. During this time cattle were the primary domestic grazers in the area.

Natural fire was a frequent ecological driver of this Ecological Site however due to the relatively low plant density and fire resistant plants (saltbush and greasewood) stand replacement was rare. The reference community with a high amount of herbaceous growth as a result of favorable growing conditions has the highest susceptibility to extreme fire. A herbaceous invaded community that contains high amounts of exotic annual grasses can greatly

increase risk of fire frequency and intensity resulting in potential removal of native species.

Some of the major invasive species that can occur on this site include (but not limited to) spotted knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*), cheatgrass (*Bromus tectorum*), Canada thistle (*Cirsium arvense*), dandelion (*Taraxicum* spp), and Kentucky bluegrass (*Poa pratensis*). Invasive weeds have a high impact on this Ecological Site.

### Plant Communities and Transitions

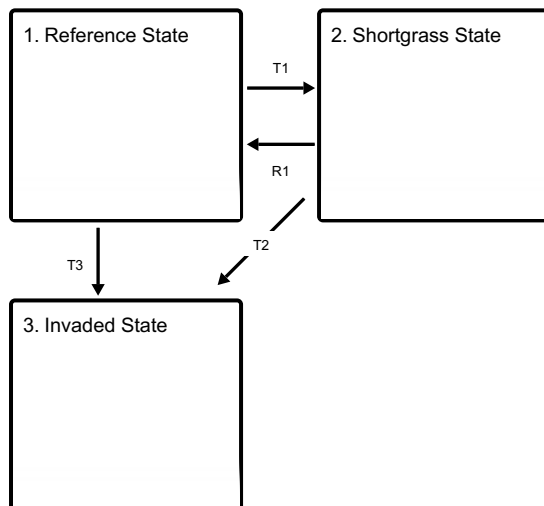
A State and Transition Model for this ecological site is depicted below. Thorough descriptions of each state, transition, plant community, and pathway follow the model. This model is based on available experimental research, field data, field observations, and interpretations by experts. It is likely to change as knowledge increases.

The plant communities within the same ecological site will differ across the MLRA due to the naturally occurring variability in weather, soils, and aspect. The biological processes on this site are complex; therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are intended to cover the core species and known range of conditions and responses. Both percent species composition by weight and percent canopy cover are referenced in this document. Canopy cover drives the transitions between communities and states because of the influence of shade, interception of rainfall and competition for available water. Species composition by dry weight remains an important descriptor of the herbaceous community and of the community as a whole. Woody species are included in species composition for the site. Calculating similarity index requires use of species composition by dry weight.

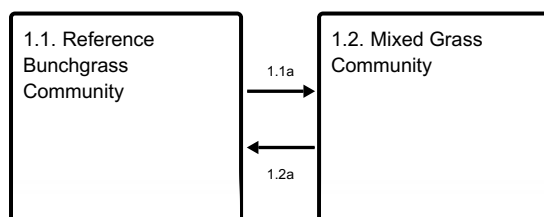
Although there is considerable qualitative experience supporting the pathways and transitions within the State and Transition Model (STM), no quantitative information exists that specifically identifies threshold parameters between grassland types and invaded types in this ecological site. For information on STMs, see the following citations: Bestelmeyer et al. 2003, Bestelmeyer et al. 2004, Bestelmeyer and Brown 2005, Stringham et al. 2003.

## State and transition model

### Ecosystem states



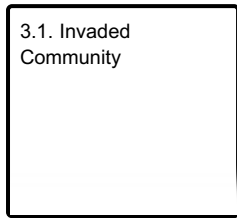
### State 1 submodel, plant communities



## State 2 submodel, plant communities



## State 3 submodel, plant communities



## State 1 Reference State

The Reference State of this ecological site consists of 2 known potential plant communities 1.1 Reference Bunchgrass Community and 1.2 Wheatgrass Community. These are described below but are generally characterized by a mid-statured, cool season grass community with limited shrub production. Community 1.1 is dominated by a mix of western wheatgrass, winterfat, basin wildrye, alkali sacaton, alkali cordgrass. Community 1.1 is considered the reference while Community 1.2 has a codominance of western wheatgrass, alkali sacaton, saltbush, Sandberg bluegrass, and other shrubs including big sagebrush and black greasewood.

### Community 1.1 Reference Bunchgrass Community

In the Reference Bunchgrass Community, basin wildrye, alkali sacaton, and western wheatgrass are dominant. On the wettest of sites, alkali cordgrass will increase. Alkalie bluegrass (now known as Sandberg bluegrass), Inland saltgrass, and prairie Junegrass are also component of the reference state. Big sagebrush, black greasewood, Gardner's saltbush, and winter fat are dominant shrubs. Forbs tend to be restricted to salt tolerant succuents such as seepweed (*Suaeda*) and poverty sumpweed (*Iva axillaris*) however several goosefoot species (*Chenopodium* spp) may also be present. About 90 percent of the annual production is from grasses and sedges, most of which is produced during the cool season. Forbs and shrubs each contribute about 5 percent to total annual production. Total vegetative production averages 3000 lbs/ac in normal years, 4500 lbs/ac in favorable years, and 1750 lbs/ac in "unfavorable" years.

### Community 1.2 Mixed Grass Community

The Mixed Grass Community is defined by a plant community formed primarily of a codominance of midstatured bunchgrasses and rhizomatous grasses with an increase in forbs and shrubs. This is typically a result of non-prescribed grazing removing some of the basin wildrye and alkali sacaton. If present, basin wildrye may be in such low density it no longer contributes to the structural integrity of the community. This community is extremely susceptible to invasive non-native species due to an increase in bare ground is expected due to a reduction of basal area occupied by the larger bunchgrasses. In this community, cheatgrass possibly exists as a trace amount which poses a risk to the hydrologic function, biotic integrity, and site stability due to its shallow rooting structure and ability to overtake areas.

### Pathway 1.1a Community 1.1 to 1.2

The community pathway from the Reference Bunchgrass Community (1.1) to the Mixed Grass Community (1.2) is primarily driven by improper grazing. When vigor declines enough for plants to die or become smaller, species with higher grazing tolerance, such as western wheatgrass and Sandberg bluegrass, increase in vigor and production as



they access the resources previously used by green needlegrass and other tall grasses. Decrease of species composition by weight of the tall grasses to be equal to that of rhizomatous grasses specifically western wheatgrass and thickspike wheatgrass indicates that the reference plant community has shifted to the Mixed Grass Community (1.2). The driver for community shift 1.1A is improper grazing management or prolonged drought. This shift is triggered by the loss of vigor of tall grasses, soil erosion, or prolonged drought coupled with improper grazing. Blaisdell (1958) stated that drought and warmer than normal temperatures are known to advance plant phenology by as much as one month. During drought years, plants may be especially sensitive or in a critical stage of development earlier than expected.

### **Pathway 1.2a**

#### **Community 1.2 to 1.1**

The Mixed Grass Community (1.2) will return to the Reference Bunchgrass Community (1.1) with proper grazing management and appropriate grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. It may take several years of favorable conditions for the community to transition back to a basin wildrye and alkali sacaton dominated state. The driver for this community shift (1.2a) is increased vigor of the tall grasses resulting in increase biomass production and dominance of plant community. The trigger for this shift is the change in grazing management favoring basin wildrye. In general, conservative grazing management styles such as deferred or rest rotations utilizing moderate grazing (less than 50% use) coupled with favorable growing conditions like cool, wet springs are these triggers. These systems tend to promote increases in soil organic matter which promotes microfauna and can increase infiltration rates. Inversely, long periods of rest at a time when this state is considered to be stable may not result in an increase in native bunchgrasses and it has been suggested (Noy-Meir 1975) that these long periods of rest or underutilization may actually drive the system to a lower level of stability by creating large amounts of standing biomass, dead plant caudex centers, and gaps in the plant canopy.

### **State 2**

#### **Shortgrass State**

State 2, Shortgrass State, has been altered by long term unmanaged, heavy grazing. In this State, drought conditions may speed the departure from reference.

### **Community 2.1**

#### **Shortgrass Community**

The Shortgrass Community (2.1) receives its name by the overall dominance of shortgrasses such as inland saltgrass, sand dropseed, sandberg bluegrass, bottlebrush squirreltail, foxtail barley, and sedges. The mid and tall warm season perennial grasses (alkali sacaton, western/thickspike wheatgrasses, alkali cordgrass, etc.) are either significantly reduced or absent. Poverty weed, knotweed, seepweed, curlycup gumweed and other forbs account for about 10% of the annual production. Winterfat is removed from this plant community and replaced by a dominance of black greasewood, saltbush, and plains pricklypear cactus. This is a result of a combination of long term drought and overgrazing (grazing that exceeds 50 percent utilization without proper rest period and/or repeated seasonal use). Amount of bare ground is moderately higher than expected. Surface salts are quite extensive.

### **State 3**

#### **Invaded State**

Site is invaded by nonnative herbaceous species primarily cheatgrass, field brome, ventenata, and halogeton. This is often a result of reduced vigor in States 1 and 2. The reduced vigor may be attributed to overgrazing however longterm drought may also trigger reduced vigor of these communities

### **Community 3.1**

#### **Invaded Community**

The Invaded Community consists primarily of non-native grasses and forbs. The primary species is cheatgrass however ventenata is known to be present in this MLRA allowing for rapid invasion. There tends to be an increase in sagebrush and greasewood cover. Native grasses are often limited to short bunchgrasses although some taller grasses may exist in the protective bases of shrubs. The increase of annual grasses can increase the intensity and

severity of wildfire. The transition to this community is driven by 2 likely disturbances. The first being repeated heavy, unmanaged grazing and the other is intense fire. These often occur in combination which creates bare ground, depletes organic matter, and increases evapotranspiration. Extensive restoration practices are needed to make this community resemble the reference state however it will never return to reference due to the severe departure and often loss of soil resources needed to maintain reference. Restoration to a community that resembles reference will require extensive and expensive inputs such as pest management, brush management and range seeding however removal of existing species may actually accelerate erosion of the soil surface if not properly managed.

### **Transition T1 State 1 to 2**

This transition is often triggered by long term overgrazing or other human disturbances. Long term drought or altered hydrologic function is also a factor. This system is seasonally wet and if a drying cycle lasts long enough health and vigor of the species present is reduced which allows short grasses to take advantage of limited water resources on the potentially reduced salinity of the soil surface.

### **Transition T3 State 1 to 3**

Invasion of the community by nonnative herbaceous species including cheatgrass, field brome, and halogeton (*Halogeton glomerata*). Often as a result of long term overgrazing and/or intense fire which reduces vigor of native herbaceous species. This transition is often irreversible due to the high salinity as well as seasonally wet soil conditions.

### **Restoration pathway R1 State 2 to 1**

Improved grazing management with favorable growing conditions may allow deep rooted bunchgrasses to reestablish dominance. Limited prescribed fire may reduce vigor of shortgrasses and shrubs temporarily. Due to the potentially wet soil conditions associated with this site mechanical alteration of the soil and vegetation is not recommended.

### **Transition T2 State 2 to 3**

Invasion of the community by nonnative herbaceous species including cheatgrass, field brome, and halogeton (*Halogeton glomerata*). Often as a result of long term overgrazing and/or intense fire which reduces vigor of native herbaceous species. This transition is often irreversible due to the high salinity.

## **Additional community tables**

### **Animal community**

The Saline Lowland Ecological site provides for a variety of wildlife habitat for an array of species. Prior to the settlement of this area, large herds of antelope, elk and bison roamed. Though the bison that once utilized this landscape have been replaced with domestic livestock, wildlife still utilize this largely intact landscape for habitat. The relatively high grass component of the Reference Community provides excellent nesting cover for multiple neotropical migratory birds as well as provide hiding habitat for larger animals. Greater Sage Grouse likely utilize most states of this ecological site as there are high amounts of forbs and insects as a result of the favorable soil moisture. Even in the Shortgrass State, sage grouse will utilize the increased forb and shrub cover for both foraging and hiding cover. This site would be considered critical habitat for most life stages of Greater Sage Grouse.

Managed livestock grazing is suitable on this site due to the potential to produce an abundance of high quality forage. This is often a preferred site for grazing by livestock, and animals tend to congregate in these areas. In order to maintain the productivity of this site, grazing on adjoining sites with less production must be managed carefully to be sure utilization on this site is not excessive. Management objectives should include maintenance or

improvement of the native plant community. Careful management of timing and duration of grazing is important. Shorter grazing periods and adequate deferment during the growing season are recommended for plant maintenance, health, and recovery.

Continual non-prescribed grazing of this site will be injurious, will alter the plant composition and production over time, and will result in transition to the Shortgrass State. Transition to other states will depend on duration of poorly managed grazing as well as other circumstances such as weather conditions and fire frequency. Further degradation will result in transition to the Invaded State. Management should focus on grazing management strategies that will prevent further degradation, such as seasonal grazing deferment or winter grazing where feasible. Communities within this state are still stable and healthy under proper management. Forage quantity and/or quality may be substantially decreased from the Reference State.

Grazing is possible in the Invaded State. Invasive species are generally less palatable than native grasses. Forage production is typically greatly reduced in this state. Due to the aggressive nature of invasive species, sites in the Invaded State face increased risk for further degradation. Grazing has to be carefully managed to avoid further soil loss and degradation and possible livestock health issues.

Prescriptive grazing can be used to manage invasive species. In some instances, carefully targeted grazing (sometimes in combination with other treatments) can reduce or maintain species composition of invasive species.

### **Inventory data references**

Information presented was derived from NRCS inventory data, National Resources Inventory (NRI) data, literature, field observations, and personal contacts with range-trained personnel (i.e., used professional opinion of agency specialists, observations of land managers, and outside scientists).

### **Other references**

McLean, A. and S. Wikeem. 1985. Influence of season and intensity of defoliation on bluebunch wheatgrass survival and vigor in southern British Columbia. *Journal of Range Management* 38:21–26.

Ross, R.L., E.P. Murray, and J.G. Haigh. July 1973. Soil and Vegetation of Near-pristine sites in Montana.

Colberg, T.J. and J.T. Romo. 2003. Clubmoss effects on plant water status and standing crop. *Journal of Range Management* 56:489–495.

Walker, L.R. and S.D. Smith. 1997. Impacts of invasive plants on community and ecosystem properties. Pages 69–86 in *Assessment and management of plant invasions*. Springer, New York, NY.

Barrett, H. 2007. *Western Juniper Management: A Field Guide*.

Miller, R.F., T.J. Svejcar, and J.A. Rose. 2000. Impacts of western juniper on plant community composition and structure. *Journal of Range Management* 53:574–585.

Masters, R. and R. Sheley. 2001. Principles and practices for managing rangeland invasive plants. *Journal of Range Management* 38:21–26.

Hobbs, J.R. and S.E. Humphries. 1995. An integrated approach to the ecology and management of plant invasions. *Conservation Biology* 9:761–770.

DiTomaso, J.M. 2000. Invasive weeds in Rangelands: Species, Impacts, and Management. *Weed Science* 48:255–265.

Dormaer, J.F., B.W. Adams, and W.D. Willms. 1997. Impacts of rotational grazing on mixed prairie soils and vegetation. *Journal of Range Management* 50:647–651.

Smoliak, S., R.L. Ditterlin, J.D. Scheetz, L.K. Holzworth, J.R. Sims, L.E. Wiesner, D.E. Baldrige, and G.L. Tibke. 2006. *Montana Interagency Plant Materials Handbook*.

Wilson, A.M., G.A. Harris, and D.H. Gates. 1966. Cumulative Effects of Clipping on Yield of Bluebunch wheatgrass. *Journal of Range Management* 19:90–91.

Blaisdell, J.P. 1958. Seasonal development and yield of native plants on the Upper Snake River Plains and their relation to certain climate factors.

Whitford, W.G., E.F. Aldon, D.W. Freckman, Y. Steinberger, and L.W. Parker. 1989. Effects of Organic Amendments on Soil Biota on a Degraded Rangeland. *Journal of Range Management* 41:56–60.

Stavi, I. 2012. The potential use of biochar in reclaiming degraded rangelands. *Journal of Environmental Planning and Management* 55:1–9.

Bestelmeyer, B., J.R. Brown, J.E. Herrick, D.A. Trujillo, and K.M. Havstad. 2004. Land Management in the American Southwest: a state-and-transition approach to ecosystem complexity. *Environmental Management* 34:38–51.

Bestelmeyer, B. and J. Brown. 2005. State-and-Transition Models 101: A Fresh look at vegetation change.

Stringham, T.K., W.C. Kreuger, and P.L. Shaver. 2003. State and Transition Modeling: an ecological process approach. *Journal of Range Management* 56:106–113.

Stringham, T.K. and W.C. Krueger. 2001. States, Transitions, and Thresholds: Further refinement for rangeland applications.

Stavi, I 2012. The potential use of biochar in reclaiming degraded rangelands. *Journal of Environmental Planning and Management* 55:1-9

Humphrey, L. David. 1984. Patterns and mechanisms of plant succession after fire on Artemisia-grass sites in southeastern Idaho *Vegetation*. 57: 91-101.

Tirmenstein, D. 1999. *Gutierrezia sarothrae*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). <https://www.fs.fed.us/database/feis/plants/shrub/gutsar/all.html> [2022, March 30].

## Contributors

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## Approval

Kirt Walstad, 9/07/2023

## 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.

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Date	08/05/2020
Approved by	Kirt Walstad
Approval date	

## Indicators

1. **Number and extent of rills:** Rills are not present in the reference state

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2. **Presence of water flow patterns:** Water flow patterns will not be present in the Reference State

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3. **Number and height of erosional pedestals or terracettes:** Pedestals and terracettes will not be present in the Reference State

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is extremely limited due to high amounts of herbaceous growth and litter. Bare ground may be expressed in very small patches of up to 5 percent.

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5. **Number of gullies and erosion associated with gullies:** Gullies will not be present in the Reference State

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Wind scoured, blowouts, and/or depositional areas will not be present in the Reference State.

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7. **Amount of litter movement (describe size and distance expected to travel):** No litter movement is expected in the Reference State.

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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):** This site is stable due to deep rooted nature of the bunchgrass dominated community. Stability ratings of 5 to 6 under both canopy and ratings of 3-5 in plant interspaces are expected. .

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil Structure at the surface is weak subangular blocky to weak fine granular. A Horizon should be 4-8 inches thick with color, when wet, typically ranging in Value of 5 or less and Chroma of 4 or less.  
  
Local geology may affect color, it is important to reference the Official Series Description (OSD) for characteristic range. <https://soilseries.sc.egov.usda.gov/osdname.aspx>

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** 90-95% plant canopy and 80-85% basal cover with small gaps between plants should reduce raindrop impact and slow overland flow, providing increased time for infiltration to occur. Healthy, deep rooted native grasses enhance infiltration and reduce runoff. Infiltration rate is moderate to very slow. If in plant community A, 90-95% plant canopy and 70-80% basal cover with small gaps between plants will still reduce raindrop

impact and decrease overland flow.

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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):** A compaction layer is not present in the reference condition. Soil profile may contain an abrupt transition to an Argillic horizon which can be misinterpreted as compaction, however, the soil structure will be fine to medium subangular blocky, where a compaction layer will be platy or structureless (massive).
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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: Tall, warm season bunch grasses = mid-stature, cool season bunch grasses > mid-stature cool season rhizomatous grasses > sedges and rushes > short, warm season rhizomatous grasses

Sub-dominant: forbs = shrubs.

Other:

Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Mortality in herbaceous species is not evident. Species with bunch growth forms may have some natural mortality in centers is 3% or less.
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14. **Average percent litter cover (%) and depth ( in):** Litter cover is high and ranges from 50-65 percent. Litter depth is highly variable from nearly immeasurable in plant interspaces to very thick (1 inch) under plants. Averages are 0.25 to 0.5 inches deep.
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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** Total vegetative production averages 3000 lbs/ac, 4500 lbs/ac as a high, and 1750 lbs/ac as a low

Production varies based on effective precipitation and natural variability of soil properties for this ecological site.

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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:** Potential invasive (including noxious) species (native and non-native). Invasive species on this ecological site include (but not limited to): annual brome spp., spotted knapweed, leafy spurge, crested wheatgrass, salsify, and halogeton

Native species such as rocky mtn Juniper, ponderosa pine, pricklypear cactus, broom snakeweed, Sandberg's bluegrass, etc. when their populations are significant enough to affect ecological function, indicate site condition departure.

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17. **Perennial plant reproductive capability:** In the reference condition, all plants are vigorous enough for reproduction either by seed or rhizomes in order to balance natural mortality with species recruitment.
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