Ecological site EX044B01A020
Gravelly (Gr) 10-14" PZ Frigid

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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): 044B–Central Rocky Mountain Valleys

Major Land Resource Area (MLRA) 44B, Central Rocky Mountain Valleys, is nearly 3.7 million acres of southwest Montana and borders two MLRAs: 43B Central Rocky Mountains and Foothills and 46 Northern and Central Rocky Mountain Foothills.

The major watersheds of this MLRA are those of the Missouri and Yellowstone Rivers and their associated headwaters such as the Beaverhead, Big Hole, Jefferson, Ruby, Madison, Gallatin, and Shields Rivers. These waters allow for extensive irrigation for crop production in an area that would generally only be compatible with rangeland and grazing. The Missouri River and its headwaters are behind several reservoirs that supply irrigation water, hydroelectric power, and municipal water. Limited portions of the MLRA are west of the Continental Divide along the Clark Fork River.

The primary land use of this MLRA is production agriculture (grazing, small grain production, and hay), but there is some limited mining. Urban development is high with large expanses of rangeland converted to subdivisions for a rapidly growing population.

The MLRA consists of one Land Resource Unit (LRU) and seven climate based LRU subsets. These subsets are based on a combination of Relative Effective Annual Precipitation (REAP) and frost free days. Each subset expresses a distinct set of plants that differentiate it from other LRU subsets. Annual precipitation ranges from a low of 9 inches to a high near 24 inches. The driest areas tend to be in the valley bottoms of southwest Montana in the rain shadow of the mountains. The wettest portions tend to be near the edge of the MLRA at the border with MLRA 43B. Frost free days also vary widely from less than 30 days in the Big Hole Valley to around 110 days in the warm valleys along the Yellowstone and Missouri Rivers.

The plant communities of the MRLA are highly variable, but the dominant community is a cool-season grass and shrub-steppe community. Warm-season grasses have an extremely limited extent in this MLRA. Most subspecies of big sagebrush are present, to some degree, across the MLRA.

LRU notes

MLRA 44B has one LRU that covers the entire MLRA. The LRU has been broken into seven climate subsets based on a combination of Relative Effective Annual Precipitation (REAP) and frost free days. Each combination of REAP and frost free days results in a common plant community that is shared across the subset. Each subset is giving a letter designation of A through F for sites that do not receive additional water and Y for sites that receive additional water.

LRU 01 Subset A has a REAP of nine to 14 inches (228.6-355.6mm) with a frost free days range of 70 to 110 days. This combination of REAP and frost free days results in a nearly treeless sagebrush steppe landscape.

The soil moisture regime is Ustic, dry that borders on Aridic and has a Frigid soil temperature regime.

Classification relationships

Grassland and Shrubland Habitat Types of Western Montana. (Mueggler and Stewart 1980)
1. Agropyron spicatum/*Bouteloua gracilis* habitat type
2. *Artemisia tridentata*/Agropyron spicatum habitat type

EPA Ecoregions of North America (US EPA 2013)
Level I: Northwestern Forested Mountains
Level II: Western Cordillera
Level III: Middle Rockies and Northwestern Great Plains
Level IV: Paradise Valley
Townsend Basin
Dry Intermontane Sagebrush Valleys
Shield-Smith Valleys

USDA Forest Service National Hierarchical Framework of Ecological Units (Cleland et al. 2007):
Domain: Dry
Division: M330 – Temperate Steppe Division – Mountain Provinces
Province: M332 –Middle Rocky Mountain Steppe – Coniferous Forest – Alpine Meadow
Section: M332D – Belt Mountains Section
M332E – Beaverhead Mountains Section
Subsection: M332Ej – Southwest Montana Intermontane Basins and Valleys
M332Dk – Central Montana Broad Valleys

Ecological site concept

The Gravelly ecological site is an upland site formed from alluvium or slope alluvium and is on slopes less than 15 percent. The site does not receive additional moisture from a water table or flooding. It is moderately deep to very deep site and has no root-restrictive layers within 20 inches (50cm). The surface of the site has less than five percent stone. The soil is sandy skeletal within 10 inches of the surface. The site does not have saline or saline-sodic influences and is not strongly or violently effervescent within four inches of the mineral surface. This site occurs on abandoned stream terraces near major waterways, drainages, outwash fans, and terrace escarpments.

Associated sites

EX044B01A032	**Loamy (Lo) 10-14" PZ Frigid** The Loamy ecological site occupies similar landscape position and has as similar plant community.
EX044B01A134	**Shallow to Gravel (SwGr) 10-14" PZ Frigid** The Shallow to Gravel ecological site occupies similar shoulder and summit positions.

Similar sites

EX044B01A134	**Shallow to Gravel (SwGr) 10-14" PZ Frigid** The Shallow to Gravel ecological site shares a similar Reference State Plant community as well as pathways and response to management but expresses slightly higher production values and exists on the shoulder and summit positions on the landscape.
EX044B01A110	**Sandy (Sy) 10-14" PZ Frigid** The Sandy ecological site shares a similar Reference State Plant community as well as pathways and response to management, but expresses higher production values and a different shrub component.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata*

Herbaceous	(1) *Pseudoroegneria spicata* (2) *Hesperostipa comata*

Legacy ID

R044BA020MT

Physiographic features

This site occurs on abandoned stream terraces near major waterways, drainages, outwash fans, and terrace escarpments. Slopes are typically less than 8 percent however variations may exist up to 15 percent.

Table 2. Representative physiographic features

Geomorphic position, terraces	(1) Tread
Landforms	(1) Intermontane basin > Stream terrace (2) Intermontane basin > Outwash terrace (3) Intermontane basin > Fan remnant
Flooding frequency	None to very rare
Elevation	4,200–6,500 ft
Slope	1–8%
Water table depth	60 in

Climatic features

The Central Rocky Mountain Valleys MLRA has a continental climate and some of Montana's driest areas are located in sheltered mountain valleys due to the rain-shadow effects of the neighboring mountain ranges. The average precipitation for LRU 01 Subset A is 12 inches (305mm), and the frost-free period averages 78 days. Fifty to 60 percent of the annual precipitation falls between May and August and precipitation is highest in May and June.

Table 3. Representative climatic features

Frost-free period (characteristic range)	70-110 days
Freeze-free period (characteristic range)	110-140 days
Precipitation total (characteristic range)	9-14 in
Frost-free period (actual range)	70-110 days
Freeze-free period (actual range)	110-140 days
Precipitation total (actual range)	9-14 in
Frost-free period (average)	78 days
Freeze-free period (average)	125 days
Precipitation total (average)	12 in

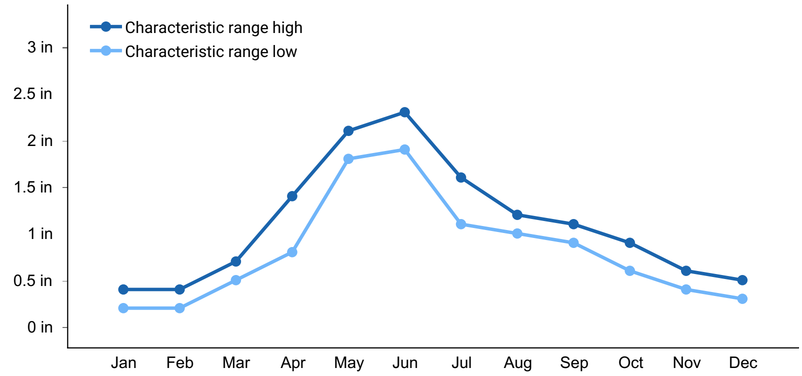


Figure 1. Monthly precipitation range

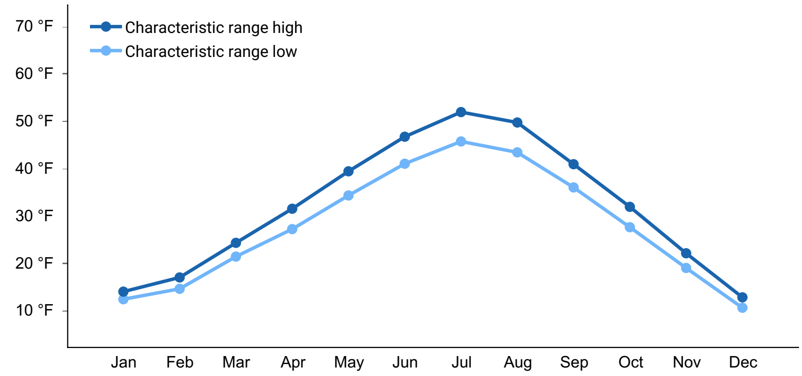


Figure 2. Monthly minimum temperature range

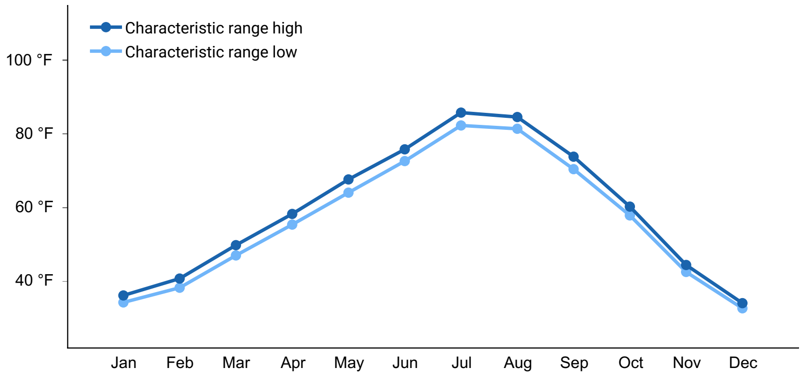


Figure 3. Monthly maximum temperature range

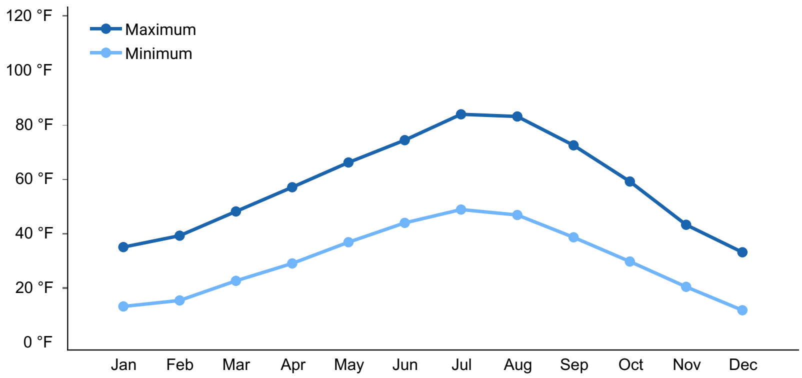


Figure 4. Monthly average minimum and maximum temperature

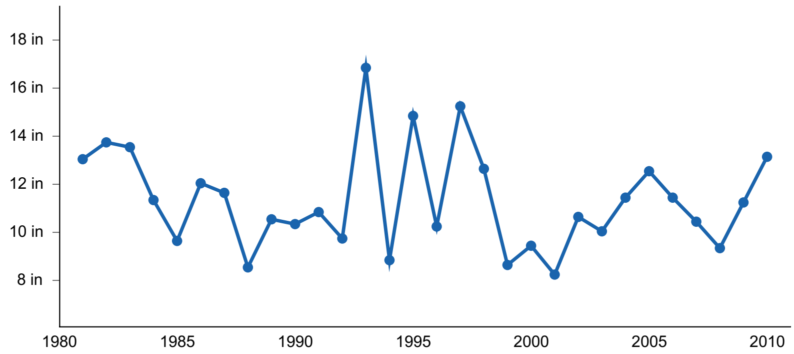


Figure 5. Annual precipitation pattern

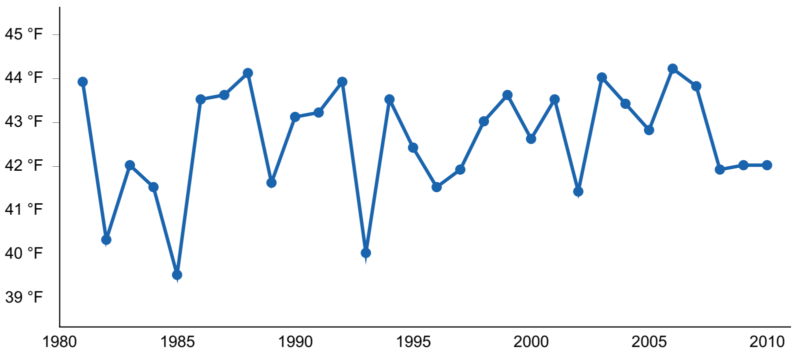


Figure 6. Annual average temperature pattern

Climate stations used

- (1) DEER LODGE 3 W [USC00242275], Deer Lodge, MT
- (2) DILLION U OF MONTANA WESTERN [USC00242409], Dillon, MT
- (3) GLEN 2 E [USC00243570], Dillon, MT
- (4) ENNIS [USC00242793], Ennis, MT
- (5) BOULDER [USC00241008], Boulder, MT
- (6) GARDINER [USC00243378], Gardiner, MT
- (7) TOWNSEND [USC00248324], Townsend, MT
- (8) TRIDENT [USC00248363], Three Forks, MT
- (9) TWIN BRIDGES [USC00248430], Sheridan, MT
- (10) WHITE SULPHUR SPRNGS 2 [USC00248930], White Sulphur Springs, MT
- (11) DILLON AP [USW00024138], Dillon, MT
- (12) HELENA RGNL AP [USW00024144], Helena, MT

Influencing water features

This ecological site often exists on stream terraces, fan remnants, and outwash terraces. This site does not have a water table that influences the plant community. Previous fluvial processes no longer exist on this site; however, evidence of alluviation may be visible in the soil profile, such as stratification, sorting of mixed geology, and rounded stones.

Wetland description

This site is not associated with wetlands.

Soil features

These soils are moderately deep to very deep, have moderately rapid to very rapid permeability, and are well to excessively drained. These soils formed from alluvium of mixed origin. Typically soil surface textures consist of sandy loam, and loamy sand. Soils often have a gravelly, cobbly, or very cobbly surface. Common soil series in this ecological site include Scravo and Riverrun. These soils may exist across multiple ecological sites in different map units due to natural variations in slope, texture, rock fragments, and pH. An onsite soil pit and the most current ecological site key are required to classify an ecological site.

Table 4. Representative soil features

Parent material	(1) Alluvium–igneous, metamorphic and sedimentary rock
Surface texture	(1) Gravelly sandy loam (2) Very gravelly sandy loam (3) Very cobbly sandy loam (4) Cobbly sandy loam
Family particle size	(1) Sandy or sandy-skeletal (2) Loamy-skeletal over sandy or sandy-skeletal
Drainage class	Well drained to excessively drained
Permeability class	Moderately rapid to very rapid
Soil depth	20–100 in
Surface fragment cover <=3"	5–40%
Surface fragment cover >3"	0–15%
Available water capacity (0-40in)	1.2–3.8 in
Soil reaction (1:1 water) (0-10in)	6.2–7.8
Subsurface fragment volume <=3" (0-20in)	15–50%
Subsurface fragment volume >3" (0-20in)	5–25%

Ecological dynamics

The Gravelly (Gr) ecological site reference plant community is dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*) and needle and thread (*Hesperostipa comata*). Subdominant species trend toward Sandberg bluegrass (*Poa secunda*), winterfat (*Krascheninnikovia lanata*), and Indian ricegrass (*Achnatherum hymenoides*). This potential is suggested by investigations showing a predominance of perennial grasses on near-pristine range sites (Ross et al., 1973). In the reference plant community, shrubs are a minor vegetative component.

The Gravelly ecological site occurs across a relatively large landscape, slight variations within the plant community occur due to elevation, frost-free days, and relative effective annual precipitation. Bluebunch wheatgrass, for example, occupies most known combinations of elevation and climate; however, under the drier sites within this Climate Subset, it often shares dominance with needle and thread. These warmer, drier sites also tend to exhibit higher populations of warm-season shortgrass such as blue grama and sand dropseed. Conversely, colder, wetter sites within this Climate Subset often exhibit slight increases in Wyoming big sagebrush production, while bluebunch wheatgrass production also increases.

A shift to the dominance of shrubs may occur in response to improper grazing management, drought, or where Wyoming big sagebrush occurs due to a lack of fire. Shrub encroachment by a variety of species, including, broom snakeweed (*Gutierrezia sarothrae*), prairie sagewort (*Artemisia frigida*), Wyoming big sagebrush (*Artemisia tridentata* ssp. wyomingensis), rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), and plains prickly pear (*Opuntia polyacantha*) occur within this site as the mid-stature bunchgrasses decrease. Shrub dominance and grass loss are associated with soil erosion and, ultimately, thinning of the native soil surface. Subsequent loss of soil could lead to a Degraded Shortgrass State. All states could also lead to the Invaded State when there is a lack of weed prevention and control measures.

Historical records indicate that, prior to the introduction of livestock (cattle and sheep) during the late 1800s, elk and bison grazed this ecological site. Due to bison's nomadic nature and herd structure, grazed areas received periodic high intensity, short duration grazing pressure. Livestock forage was noted as being minimal in areas recently grazed by bison (Lesica and Cooper 1997). Meriwether Lewis documented that he was met by 60 Shoshone warriors on horseback in August 1805, and the Corps of Discovery was later supplied with horses by the same band of Shoshone. This suggests that the areas near the modern-day Montana towns of Twin Bridges, Dillon, Grant, and Dell were grazed by an untold number of horses for nearly 50 years prior to the large introduction of cattle and sheep. The gold boom of 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. In the 1890s, sheep production increased by more than 400 percent and dominated the livestock industry until the 1930s. Since then, cattle production has dominated the livestock industry of the region (Wyckoff and Hansen 2001).

Some of the major invasive species that can occur on this site include spotted knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*), and cheatgrass (*Bromus tectorum*). Nonnative invasive weeds are common in most of this ecological site, but they tend to occupy small patches near traditional watering facilities, along roads, and other areas that receive high soil disturbance.

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.

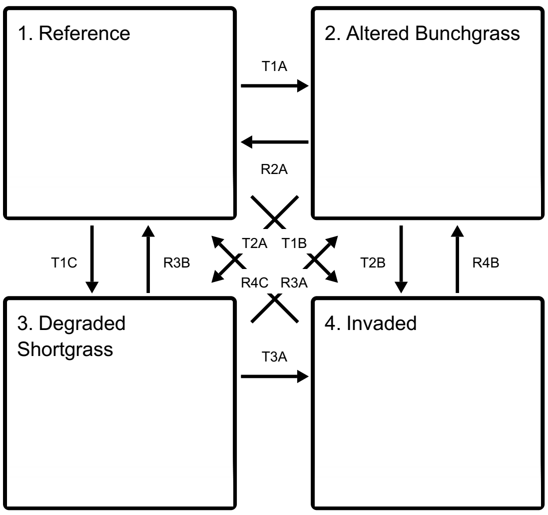
The plant communities within the same ecological site will differ across the MLRA due to the naturally occurring variability in weather, soils, and aspect. The biological processes on this site are complex; therefore, representative values are presented in a land management context. The species lists 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 the 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, the interception of rainfall, and the 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 the species composition for the site. Calculating the similarity index requires species composition by dry weight.

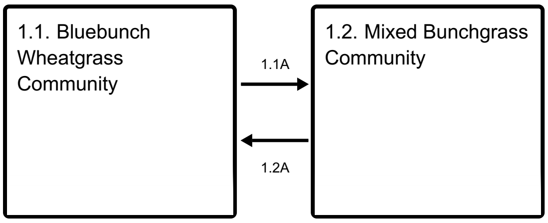
Although there is considerable qualitative experience supporting the pathways and transitions within the state and transition model (STM), no quantitative information exists that specifically identifies threshold parameters between grassland types and invaded types in this ecological site.

State and transition model

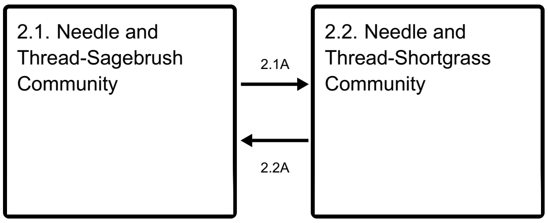
Ecosystem states



State 1 submodel, plant communities

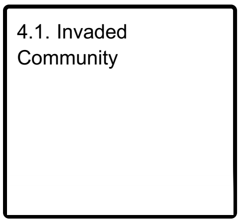


State 2 submodel, plant communities



State 3 submodel, plant communities

State 4 submodel, plant communities



State 1
Reference

The Reference State of this ecological site consists of two known potential plant communities, the Bluebunch Community and the Mixed Bluebunch 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 bluebunch wheatgrass and is considered the reference, while Community 1.2 has a codominance of bluebunch and needle and thread with an increase in green rabbitbrush and Wyoming big sagebrush. These communities may meld into each other due to the varying conditions that occur in Southwest Montana, particularly during dry cycles where needle and thread growth cycle takes better advantage of the limited moisture.

Community 1.1
Bluebunch Wheatgrass Community

In this community, bluebunch wheatgrass (*Pseudoroegneria spicata*) and needle and thread (*Hesperostipa comata*) are typically dominant. Indian ricegrass (*Achnatherum hymenoides*), Wyoming big sagebrush, and winterfat (*Krascheninnikovia lanata*) are subordinates. Shrub species such as Gardner’s saltbush and black sagebrush (*Artemisia nova*) also occur at lower production values. Sandberg bluegrass (*Poa secunda*), blue grama, sand dropseed (*Sporobolus cryptandrus*) and dryland sedges are also common. This state occurs on the Gravelly site in areas with long-term, conservative livestock grazing or in areas that receive only dormant season grazing pressure. Bluebunch wheatgrass lacks resistance to grazing during the critical growing season (spring). It will decline in vigor and production if grazed in the critical growing season more than one year out of three (Wilson et al., 1960). The reference state is moderately resilient and will return to dynamic equilibrium after a relatively short period of stress (such as drought or short-term improper grazing) if favorable or normal growing conditions and properly managed grazing are restored. Shrubs can make up a portion of the Reference Plant Community, including Wyoming big sagebrush, winterfat, and Gardner’s saltbush. Infrequent fire likely maintained Wyoming big sagebrush communities as open, seral stands of Wyoming big sagebrush with productive herbaceous understories. Wyoming big sagebrush steppe communities historically had low fuel loadings and were characterized by 10- to 70-year interval, fires that produced a mosaic of burned and unburned lands (Bunting, et.al. 1987). Following fire on the fine-textured soils, the perennial bunchgrasses recovered in a few years and were present to fuel a subsequent fire. Conversely, extensive wildfires burning under hot, dry conditions would have resulted in nearly complete destruction of scattered sagebrush (Arno and Gruell 1983). Gardner's saltbush is described as fire resistant because it contains high concentrations of minerals that increase char formation, but have low concentrations of volatile, flammable compounds (West 1994). Winterfat is tolerant of low intensity fire but will kill with a hot fire (Pellant 1984).

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	530	744	890
Forb	63	87	107
Shrub/Vine	32	44	53
Total	**625**	**875**	**1050**

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0-2%
Litter	15-30%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 7. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	1-5%
Grass/grasslike basal cover	45-65%
Forb basal cover	5-10%
Non-vascular plants	0%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	5-40%
Surface fragments >3"	0-15%
Bedrock	0%
Water	0%
Bare ground	20-25%

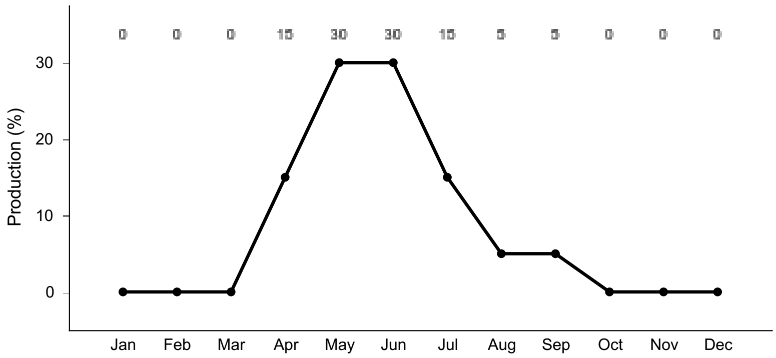


Figure 8. Plant community growth curve (percent production by month). MT44B032, Dry Uplands. Cool season grass dominated system. Most dry, upland sites located within MLRA 44B LRU A are characterized by early season growth which is mostly complete by Mid-July. Limited fall "green-up" if conditions allow..

Community 1.2
Mixed Bunchgrass Community

Needle and thread tolerates grazing pressure better than bluebunch wheatgrass. Bluebunch wheatgrass grass has a growing point several inches above the ground, making it vulnerable to continued close grazing (Smoleack et al., 2006). It increases in species composition when more palatable and less grazing-tolerant plants decrease due to improper grazing management. Needle and thread and bluebunch wheatgrass share dominance in the Mixed Bunchgrass Community (1.2). Other grass species that are more tolerant to grazing and are likely to increase in number compared to the Reference Plant Community include Sandberg bluegrass (*Poa secunda*), prairie Junegrass, western/thickspike wheatgrass (*Pascopyrum smithii*, *Elymus lanceolatus*), and blue grama (*Bouteloua gracilis*). Western yarrow, Hoods phlox (*Phlox hoodii*), scarlet globemallow (*Sphaeralcea coccinea*), hairy goldenaster, and pussytoes (Antennaria spp.) are examples of increaser forbs. Fringed sagewort (*Artemisia frigida*) can also increase under prolonged drought or heavy grazing and can respond to precipitation that falls in July and August. Heavy, continuous grazing will reduce plant cover, litter, and mulch. The timing of grazing is important on this site because of the moisture limitations beyond June, especially on the drier sites. Bare ground will increase, exposing the soil to erosion. Litter and mulch will be reduced as plant cover declines. As long as the production of bluebunch wheatgrass is over 20 percent of total biomass production, the site can be returned to the Bluebunch Wheatgrass Community (Pathway 1.2A) under proper grazing management and favorable growing conditions. Needle and thread will continue to proliferate until they account for the majority of species composition. Once bluebunch wheatgrass has been reduced to less than 25 percent, it may be difficult for the site to recover to its original Bluebunch Wheatgrass Community (1.1). The risk of soil erosion increases when canopy cover decreases below 50 percent. As soil conditions degrade, there will be a loss of organic matter, reduced litter, and reduced soil fertility. Degraded soil conditions increase the difficulty of reestablishing bluebunch wheatgrass and returning to the Reference Community (1.1). The Mixed Bunchgrass Community (1.2) is the at-risk plant community for this ecological site. When overgrazing continues, increaser species such as needle-and-thread and native forb species will become more dominant, and this triggers the change to the Altered Bunchgrass State (2) or the Degraded Shortgrass State (3). Until the Mixed Bunchgrass Community (1.2) crosses the threshold into the Needle and Thread Community (2.1) or the Invaded Community (4.1), this community can be managed toward the Bluebunch Wheatgrass Community (1.1) using prescribed grazing and strategic weed control. It may take several years to achieve this recovery, depending on growing conditions, the vigor of remnant bluebunch wheatgrass plants, and the aggressiveness of the weed treatments.

Pathway 1.1A
Community 1.1 to 1.2

Bluebunch wheatgrass loses vigor with improper grazing or extended drought. When vigor declines enough for plants to die or become smaller, species with higher grazing tolerance (needle and thread) increase in vigor and production as they access the resources previously used by bluebunch wheatgrass. The decrease in species composition by weight of bluebunch wheatgrass to less than 25 percent indicates that the plant community has shifted to the Mixed Bunchgrass 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 bluebunch wheatgrass, 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 reach a critical stage of development earlier than expected. Because needle and thread usually blooms in June and bluebunch wheatgrass blooms in July, this should be considered when planning grazing management.

Pathway 1.2A
Community 1.2 to 1.1

The Mixed Bunchgrass Community (1.2) will return to the Bluebunch Wheatgrass 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 bluebunch-dominated state. The driver for this community shift (1.2A) is the increased vigor of bluebunch wheatgrass, to the point that it represents more than 25 percent of species composition. The trigger for this shift is the change in grazing management favoring bluebunch wheatgrass.

Conservation practices

Prescribed Grazing

State 2
Altered Bunchgrass

This state is characterized by having less than 10 percent bluebunch wheatgrass by dry weight. It is represented by two communities that differ in the percent composition of needle and thread, production, and soil degradation. Production in this state can be similar to that in the Reference State (1). Some native plants tend to increase under prolonged drought and heavy grazing practices. A few of these species may include needle and thread, prairie Junegrass, Sandberg bluegrass, scarlet globemallow, hairy goldenaster, and fringed sagewort. The Lewis and Clark journals (Moulton 1988) discuss areas of Montana around north of Dillon and Horse Prairie: “The soil of the plains is a light yellow clay very meager and intermixed with a large proportion of gravel, producing nothing except the twisted or bearded grass, sedge and prickly pears”. Many of their travels were hampered because of the awns of needle and thread in their moccasins. This may suggest that there was extensive, repeated use prior to the Corps of Discovery expedition. Today, needle and thread dominates that area, suggesting that transitioning from the Altered Bunchgrass State back to the Reference State may require multiple years of recovery, without input, reaffirming the Domaar 1997 study.

Community 2.1
Needle and Thread-Sagebrush Community

Long-term grazing mismanagement with continuous growing-season pressure will reduce the total productivity of the site and lead to an increase in bare ground. Once plant cover is reduced, the site is more susceptible to erosion and degradation of soil properties. Soil erosion or reduced soil fertility will result in reduced plant production. This soil erosion or loss of soil fertility indicates the transition to the Altered Bunchgrass State (2) because it creates a threshold requiring energy input to return to the Reference State (1). Transition to the Needle and Thread-Sagebrush Community (2.1) may be exacerbated by extended drought conditions. Needle and thread dominates this community. Bluebunch wheatgrass makes up less than 10 percent of the species composition by dry weight, and the remaining bluebunch wheatgrass plants tend to be scattered and low in vigor. Increaser and invader species will be more common and create more competition for bluebunch wheatgrass. This makes it difficult for bluebunch wheatgrass to quickly respond to a change in grazing management alone. Therefore, an input of energy is required for the community to return to the Reference State (1). Wind and water erosion may be eroding soil from the plant interspaces. Soil fertility is reduced, and soil surface erosion resistance has declined compared to the Reference State (1). This community crossed a threshold compared to the Mixed Bunchgrass Community (1.2) due to the erosion of soil, vegetation composition, loss of soil fertility, or degradation of soil conditions. This results in a critical shift in the ecology of the site. The effects of soil erosion can alter the hydrology, soil chemistry, soil microorganisms, and soil structure to the point where intensive restoration is required to restore the site to another state or community. Changing grazing management alone cannot create sufficient improvement to restore the site within a reasonable time frame. Dormaar (1997) stated that with decreased grazing pressure, a needle and thread/blue grama plant community did not change species composition, but the content of the soil carbon increased. It will require a considerable input of energy to move the site back to the Reference State (1). This state has lost soil or vegetation attributes to the point that recovery to the Reference State will require reclamation efforts, e.g., soil rebuilding, intensive mechanical treatments, and/or reseeding. The transition to this state could result from overgrazing, especially repeated early-season grazing, or extensive drought. If heavy grazing continues, plant cover, litter, and mulch will continue to decrease and bare ground will increase exposing the soil to accelerated erosion. Litter will move off-site as plant cover declines. The Needle and thread-Sagebrush Community will then shift to a Needle and Thread-Shortgrass Community (2.2). Continued improper grazing will drive the community to a Degraded Shortgrass State (3). Introduction or expansion of invasive species will further drive the plant community to the Invaded State (4).

Community 2.2
Needle and Thread-Shortgrass Community

With continued mismanagement of grazing, especially coupled with prolonged drought, needle and thread will decrease in vigor. The bunchgrasses will decline in production as plants die or become smaller, and species with higher grazing tolerance (such as western wheatgrass) increase in vigor and production as they respond to resources previously used by the bunchgrasses. These less desirable, short-rooted species will become dominant over any mid-statured bunchgrasses.

Pathway 2.1A
Community 2.1 to 2.2

The driver for community shift 2.1A is continued improper grazing management. This shift is triggered by the continued loss of bunchgrass vigor, especially since needle-and-thread is the remaining mid-statured bunchgrass. The short-statured grasses will become more competitive and will become co-dominant with the bunch grasses. Shrubs will increase in canopy cover but generally stay above 15 percent.

Pathway 2.2A
Community 2.2 to 2.1

If proper grazing management is implemented, needle and thread may regain its vigor and move towards the Needle and Thread-Sagebrush Community (2.1). This will give grasses an advantage over invading shrubs before too much competition takes place. The advantage to grasses comes from following a conservative grazing plan where utilization is reduced and rest or deferment is incorporated since the transition from Community 2.1 to Community 2.2 is likely caused by repeated heavy utilization. Van Poolen and Lacey (1979) found that forage production increased by an average of 35 percent on western ranges when converting from heavy to moderate utilization. Shrub removal and favorable growing conditions can accelerate this process. If the site contains Wyoming big sagebrush (*Artemisia tridentata* spp. Wyomingensis), low intensity fire or mechanical treatment (Wambolt 1986) could reduce shrub competition and allow for increased vigor and the reestablishment of grass species.

State 3
Degraded Shortgrass

This is a single community state consisting of degraded rangeland consisting mostly of Sandberg bluegrass, blue grama, stunted needle and thread, rabbitbrush, broom snakeweed, and extensive bare ground.

Community 3.1
Degraded Shortgrass Community

Soil loss continues or increases to the point that native perennial grasses make up less than 200 pounds of annual dry weight production. Grass and forb cover may be very sparse or clump together. Weeds, annual species, and shrubs dominate the plant community. Mid-stature perennial bunchgrass species (e.g., needle and thread) may exist, but only in small patches. This could occur due to overgrazing (failure to adjust stocking rates to declining forage production due to increased invasive dominance), a long-term lack of fire (if Wyoming big sagebrush occurs), or the introduction of invasive species. In the most severe stages of degradation, there is a significant amount of bare ground, and large gaps occur between plants. Potential exists for soils to erode to the point that irreversible damage may occur. This is a critical shift in the ecology of the site. Soil erosion combined with a lack of organic matter deposition due to sparse vegetation creates changes to the hydrology, soil chemistry, soil microorganisms, and soil structure to the point where intensive restoration is required to restore the site to another state or community. Changing management (i.e., improving grazing management) cannot create sufficient change to restore the site within a reasonable time frame. This state is characterized by soil surface degradation and little plant soil surface cover. Shrub canopy cover is usually greater than 15 percent. Big sagebrush is replaced with a dominant community of broom snakeweed, green rabbitbrush, fringed sagewort, and plains prickly pear cactus. This state has lost soil or vegetation attributes to the point that recovery to the Reference State will require reclamation efforts, e.g., soil rebuilding, intensive mechanical treatments, and/or reseeding. This plant community may be in a terminal state that will not return to the reference state because of degraded soil conditions and loss of higher successional native plant species. Key factors of approach to transition: Decrease in grass canopy cover and production, increase of shrub canopy cover, increases in mean bare patch size, increases in soil crusting, decreases in cover of cryptobiotic crusts, decreases in soil aggregate stability, and/or evidence of erosion including water flow patterns and litter movement.

State 4
Invaded

The Invaded State is identified as being in the exponential growth phase of invader abundance, where control is a priority. Dominance (or relative dominance) of noxious or invasive species reduces species diversity, forage production, wildlife habitat, and site protection. A level of 20 percent invasive species composition by dry weight indicates that a substantial energy input will be required to create a shift to the grassland state (herbicide, mechanical treatment), even with a return to proper grazing management or favorable growing conditions. 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 the species composition of invasive species. These communities within this state will follow a path if the invasive/noxious species continue to thrive without mechanical, biological, or chemical control methods to exceed 50 percent of species composition by dry weight. The invasive nature of the weed outcompetes the present plant community. Once the weed reaches its maximum population level for this site, effective control is unlikely without massive resource inputs. After invading species have established and spread, ecological processes at the site may change (Walker and Smith 1997).

Community 4.1
Invaded Community

Communities in this state may be structurally indistinguishable from the bunchgrass state except that invasive or noxious species exceed 20 percent of species composition by dry weight. This state may also include a community similar to the Degraded Shortgrass State (3), except that invasive or noxious species exceed 20 percent of species composition by dry weight. Although there is no research to document the level of 20 percent, this is estimated to be the point in the invasion process following the lag phase based on the interpretation of Masters and Sheley (2001). For aggressive invasive species (i.e., spotted knapweed), a 20 percent threshold could be less than 10 percent. Early in the invasion process, there is a lag phase where the invasive plant populations remain small and localized for long periods before expanding exponentially (Hobbs and Humphries 1995). Production in the invaded community may vary greatly. A site dominated by spotted knapweed, where soil fertility and chemistry remain near potential, may have production near that of the reference community. A site with degraded soils and an infestation of cheatgrass may produce only 10 to 20 percent of the reference community. Once invasive species dominate the site, either in species composition by weight or in their impact on the community the threshold has been crossed to the Invaded State (4). As invasive species such as spotted knapweed, cheatgrass, and leafy spurge become established, they become very difficult to eradicate. Therefore, considerable effort should be put into preventing plant communities from crossing a threshold into the Invaded State (4) through early detection and proper management. Preventing new invasions is by far the most cost-effective control strategy, and typically places an emphasis on education. Control measures used on the noxious plant species impacting this ecological site include chemical, biological, and cultural control methods. The best success has been found with an integrated pest management (IPM) strategy that incorporates one or several of these options along with education and prevention efforts (DiTomaso 2000).

Transition T1A
State 1 to 2

The Reference State (1) transitions to the Altered Bunchgrass State (2) if bluebunch wheatgrass, by dry weight, decreases to below 10 percent or if bare ground cover increases beyond 15 percent. The trigger for this transition is the loss of taller bunchgrasses, which creates open spots with bare soil. Soil erosion results in decreased soil fertility, driving transitions to the Altered Bunchgrass State. There are several other key factors signaling the approach of transition T1A: increases in soil physical crusting, decreases in cover of cryptogamic crusts, decreases in soil surface aggregate stability, and/or evidence of erosion including water flow patterns, development of plant pedestals, and litter movement. The driver for this transition is improper grazing management and/or long-term drought, leading to a decrease in bluebunch wheatgrass composition to less than 10 percent and a reduction in total plant canopy cover.

Transition T1C
State 1 to 3

The Reference State (1) transitions to the Degraded Shortgrass State (3) when bluebunch wheatgrass is removed from the plant community and needle and thread is codominant with short-statured bunchgrasses such as Sandberg bluegrass. Most species will express a decumbent growth habit in this state. The trigger for this transition is the loss of taller bunchgrasses, which creates open spots with bare soil. Soil erosion reduces soil fertility, causing the transition to the Degraded Shortgrass State. There are several other key factors signaling the approach of transition T1C: increases in soil physical crusting, decreases in cover of cryptogamic crusts, decreases in soil surface aggregate stability, and/or evidence of erosion including water flow patterns, development of plant pedestals, and litter movement. The driver for this transition is improper grazing management and/or heavy human disturbance. Rapid transition is generally realized where livestock are confined to small pastures for long periods of time.

Transition T1B
State 1 to 4

Regardless of grazing management, without some form of active weed management (chemical, mechanical, or biological control) and prevention, the Reference State (1) can transition to the Invaded State (4) in the presence of aggressive invasive species such as spotted knapweed and cheatgrass. This will occur even if the reference community is thriving. Healthy plant communities are most resilient to invasives. Long-term stress conditions for native species (e.g., overgrazing, drought, and fire) accelerate this transition. If populations of invasive species reach critical levels, the site transitions to the Invaded State. The driver for this transition is the presence of aggressive invasive species. The species composition by dry weight of invasive species approaches 10 percent.

Restoration pathway R2A
State 2 to 1

The Altered State (2) has lost soil or vegetation attributes to the point that recovery to the Reference State (1) will require reclamation efforts such as soil rebuilding, intensive mechanical and cultural treatments, and/or revegetation. Low-intensity prescribed fires are used to reduce competitive increaser plants like needle and thread and Sandberg bluegrass. A low intensity fire will also reduce Wyoming big sagebrush densities. Fire should be carefully planned or avoided in areas prone to annual grass infestation. The drivers for this restoration pathway are reclamation efforts along with proper grazing management. The trigger is restoration efforts.

Conservation practices

Prescribed Grazing

Transition T2A
State 2 to 3

As improper grazing management continues, the vigor of bunchgrasses will decrease and the shorter grasses and shrubs will increase, leading to the Degraded Shortgrass State (3). Prolonged drought will provide a competitive advantage to shrubs, allowing them to become co-dominant with grasses. The canopy cover of shrubs will increase above 10 percent. Key transition factors include: an increase in native shrub canopy cover; a reduction in bunchgrass production; a decrease in total plant canopy cover and production; increases in mean bare patch size;

increases in soil crusting; decreases in the cover of cryptobiotic crusts; decreases in soil aggregate stability; and/or evidence of erosion, including water flow patterns and litter movement.

Transition T2B
State 2 to 4

Invasive species can occupy the Altered State (2) and drive it to the Invaded State (4). The Altered State is at risk if invasive seeds and/or other viable material are present. The driver for this transition is more than 10 percent of the dry weight of invasive species. The trigger is the presence of seeds and/or other viable material from invasive species.

Restoration pathway R3B
State 3 to 1

The Degraded Shortgrass State (3) has lost soil or vegetation attributes to the point that recovery to the Reference State (1) will require reclamation efforts, such as soil rebuilding, intensive mechanical treatments, and/or revegetation. The drivers for the restoration pathway are the removal of increaser species, restoration of native bunchgrass species, persistent management of invasives and shrubs, and proper grazing management. Without continued control, invasive and shrub species are likely to return (probably rapidly) due to the presence of seeds and/or other viable material in the soil and management-related increases in soil disturbance. The drivers for this restoration pathway are reclamation efforts and proper grazing management. The trigger is restoration efforts.

Conservation practices

Critical Area Planting
Range Planting
Integrated Pest Management (IPM)
Prescribed Grazing

Restoration pathway R3A
State 3 to 2

Since the bunchgrass plant community has been significantly reduced, restoration to the Altered State (2) is unlikely unless a seed source is available. If there is enough grass left on the site, chemical and/or biological control, combined with proper grazing management, can reduce the amount of shrubs and invasive species and restore the site to the Needle and Thread-Shortgrass Community (2.2). Low-intensity fire can be utilized to reduce Wyoming big sagebrush competition and allow the reestablishment of grass species. Caution must be used when considering fire as a management tool on sites with fire-tolerant shrubs such as rubber rabbitbrush, as these shrubs will sprout after a burn. Broom snakeweed and fringed sagewort may or may not re-sprout depending on conditions (USDA Forest Service 2011).

Conservation practices

Brush Management
Critical Area Planting
Range Planting
Integrated Pest Management (IPM)
Prescribed Grazing

Transition T3A
State 3 to 4

Invasive species can occupy the Degraded Shortgrass State (3) and drive it to the Invaded State (4). The Degraded Shortgrass State is at risk of this transition occurring if invasive seeds or viable material are present. The driver for this transition is the presence of critical population levels (more than 20 percent dry weight of invasive species). The trigger is the presence of seeds or viable material from invasive species. This state has sufficient bare ground that the transition could occur simply due to the presence or introduction of invasive seeds or viable material. This is particularly true of aggressive invasive species such as spotted knapweed. This transition could be assisted by overgrazing (failure to adjust stocking rate to declining forage production), a long-term lack of fire, or an extensive drought.

Restoration pathway R4C
State 4 to 1

Restoration of the Invaded State (4) to the Reference State (1) requires substantial energy input. The drivers for the restoration pathway are the removal of invasive species, restoration of native bunchgrass species, persistent management of invasive species, and proper grazing management. Without continued control, invasive species are likely to return (probably rapidly) due to the presence of seeds and/or other viable material in the soil and management-related practices that increase soil disturbance. The drivers for the reclamation pathway are treatments to reduce or remove invasive or noxious species in combination with favorable growing conditions. The trigger is invasive species control and possibly range reseeding.

Restoration pathway R4B
State 4 to 2

If invasive species are removed before remnant populations of bunchgrass are drastically reduced, the invading state (4) can revert to its altered state. The driver for the reclamation pathway is weed management without reseeding. Continued Integrated Pest Management (IPM) will be required as many of the invasive species that can occupy the Invaded State have extended dormant seed life. The trigger is invasive species control.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Mid-Statured Bunchgrasses**			450–569	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	375–450	–
	needle and thread	HECO26	*Hesperostipa comata*	44–110	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–60	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–44	–
2	**Rhizomatous Grasses**			40–90	
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	40–90	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0–60	–
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–30	–
2	**Shortgrasses/Grasslikes**			40–90	
	Sandberg bluegrass	POSE	*Poa secunda*	20–44	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	10–40	–
	Grass, perennial	2GP	*Grass, perennial*	0–25	–
	threadleaf sedge	CAFI	*Carex filifolia*	0–25	–
	blue grama	BOGR2	*Bouteloua gracilis*	0–20	–
	needleleaf sedge	CADU6	*Carex duriuscula*	0–10	–
Forb					
3	**Forbs**			32–50	
	hairy false goldenaster	HEVI4	*Heterotheca villosa*	0–20	–
	dotted blazing star	LIPU	*Liatris punctata*	5–15	–

	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	10–15	–
	American vetch	VIAM	*Vicia americana*	10–15	–
	ballhead sandwort	ARCO5	*Arenaria congesta*	0–10	–
	beardtongue	PENST	*Penstemon*	0–10	–
	spiny phlox	PHHO	*Phlox hoodii*	0–10	–
	Forb, perennial	2FP	*Forb, perennial*	0–10	–
	fleabane	ERIGE2	*Erigeron*	0–10	–
	buckwheat	ERIOG	*Eriogonum*	0–10	–
	desertparsley	LOMAT	*Lomatium*	0–5	–
	milkvetch	ASTRA	*Astragalus*	0–5	–
	Forb, annual	2FA	*Forb, annual*	0–5	–
Shrub/Vine					
4	**Shrubs**			60–90	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	25–50	–
	skunkbush sumac	RHTR	*Rhus trilobata*	0–50	–
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	15–40	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	25–40	–
	soapweed yucca	YUGL	*Yucca glauca*	0–25	–
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0–20	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–20	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–10	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–10	–

Animal community

The Gravelly ecological site provides a variety of wildlife habitats for an array of species. Prior to the settlement of this area, large herds of antelope, elk, and bison roamed. Though the bison have been replaced, mostly with domesticated livestock, elk and antelope still frequently utilize this largely intact landscape for winter habitat in areas adjacent to forests.

The high bunchgrass component of the Reference State provides excellent nesting cover for multiple neotropical migratory birds that select for open grasslands, such as the long-billed curlew and McCown's longspur.

Greater sage grouse may be present on sites with suitable habitat, typically requiring a minimum of 15 percent sagebrush canopy cover (Wallestad 1975). The Bunchgrass-Shrub Community (1.1) is likely to have optimal sage grouse presence given its high sagebrush canopy cover. The potentially diverse forb component of the Reference State may also provide important early-season (spring) foraging habitat for the greater sage grouse and their broods. Other communities on the site with sufficient sagebrush cover may harbor sage grouse populations, specifically Rhizomatous Community 2.1, where big sagebrush populations are under a reduced fire regime. Also, as sagebrush canopy cover increases under the Rhizomatous Community and, to a limited extent, under Shortgrass-Shrub State 3.1, pygmy rabbit, Brewer's sparrow, and mule deer use may also increase.

Managed livestock grazing is suitable on this site due to the potential to produce an abundance of high-quality forage. In order to maintain the productivity of the site, grazing on this site must be managed carefully to make sure utilization is not excessive. Management objectives should include the maintenance or improvement of the native plant community. Careful management of the timing and duration of grazing is important. Short grazing periods and adequate deferment during the growing season are recommended for plant maintenance, health, and recovery. According to McLean et al., early-season defoliation of bluebunch wheatgrass can result in high mortality and reduced vigor in plants. They also suggest, based on prior studies, that regrowth is necessary before dormancy to reduce injury to the bluebunch.

The grazing season has a greater impact on winterfat than the intensity of grazing. Late-winter or early-spring grazing is detrimental. However, early winter grazing may actually be beneficial (Blaisdell 1984).

Continual unmanaged grazing of this site will be detrimental, alter the plant composition and production over time, and result in the transition to the Rhizomatous State. The transition to other states will depend on the duration of poorly managed grazing as well as other circumstances such as weather conditions and fire frequency.

The Rhizomatous State is subject to further degradation into the Degraded Shortgrass State or Invaded State. Management should focus on grazing management strategies that will prevent further degradation, such as rest rotation, seasonal grazing deferment, or winter grazing where feasible. Communities within this state are still stable under proper management. Forage quantity and quality may be substantially decreased compared to the Reference State.

In the Degraded Shortgrass State, grazing may be possible but is generally not economically or environmentally sustainable.

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 an increased risk of further degradation by invasive-dominant communities. Grazing must be carefully managed to avoid further soil loss and degradation. 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 the species composition of invasive species.

Hydrological functions

The hydrologic cycle functions best in the Bunchgrass State (1) with good infiltration and deep percolation of rainfall; however, the cycle degrades as the vegetation community declines. Rapid rainfall infiltration, high soil organic matter, good soil structure, and good porosity accompany high bunchgrass canopy cover of around 80 percent. High ground cover reduces raindrop impact on the soil surface, which keeps erosion and sedimentation transport low. Water leaving the site will have minimal sediment load, which allows for high water quality in associated streams. High rates of infiltration will allow water to move below the rooting zone during periods of heavy rainfall. The Bluebunch Wheatgrass Community (1.1) should have no rills or gullies present and drainage ways should be vegetated and stable. Water flow patterns, if present, will be barely observable. Plant pedestals are essentially non-existent. Plant litter remains in place and is not moved by wind or water.

Improper grazing management results in a community shift to the Mixed Bunchgrass Community (1.2). This plant community has a similar canopy cover, but bare ground will be less than 15 percent. Therefore, the hydrologic cycle is functioning at a level like the water cycle in the Bluebunch Wheatgrass Community/Needle and thread (1.1). Compared to the Bluebunch Wheatgrass/Needle and thread Community (1.1) infiltration rates are slightly reduced and surface runoff is slightly higher.

In the Shortgrass Community (2.2), Degraded Shortgrass State (3) and the Invaded State (4) canopy and ground cover are greatly reduced compared to the Bunchgrass State (1), which impedes the hydrologic cycle. Infiltration will decrease and runoff will increase due to reduced ground cover, presence of shallow-rooted species, rainfall splash, soil capping, reduced organic matter, and poor structure. Sparse ground cover and decreased infiltration can combine to increase frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor, and sedimentation increases.

Recreational uses

This site provides some limited recreational opportunities for hiking, horseback riding, big game and upland bird hunting. The forbs have flowers that appeal to photographers. This site provides valuable open space.

Wood products

none

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Approval

Kirt Walstad, 2/11/2025

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	04/24/2019
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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2. **Presence of water flow patterns:** Water flow patterns are rare in the reference state. If present, they will occur on steeper slopes (10-15%) and will be inconspicuous, disconnected, and very short in length.

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3. **Number and height of erosional pedestals or terracettes:** No present

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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 between 10 and 15 percent. This refers to exposed mineral soil not covered by litter, rocks, basal cover, plant cover, standing dead, lichen, and/or moss.

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5. **Number of gullies and erosion associated with gullies:** Not Present in Reference State

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Not evident under normal conditions.

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7. **Amount of litter movement (describe size and distance expected to travel):** Movement of fine herbaceous litter may occur within less than a foot from where it originated.

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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):** Due to the coarse nature of the soil associated with this ecological site, soil stability ratings will be low. Interspaces will often have ratings of 2 and under plant canopy and plant base value ratings will be 3-5.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Organic matter values are low for this site, ranging from 1–2 percent. The surface structure is weak to medium-fine granular. A horizon's coloration is variable; however, soil will have a wet Value of 4-6 or less and Chroma of 3 or less. Local geology may affect color, making it important to refer to the Official Series Description (OSD) for the characteristic range.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Infiltration is high. Evenly distributed across the site, bunchgrasses improve infiltration while rhizomatous grass protects the surface from runoff forces. The Gravelly ecological site is well drained and has a high infiltration rate, especially in the subsurface horizons. An even distribution of Mid-Statured bunchgrasses (60–70%), rhizomatous grasses (5–10%), and a mix of short grasses (5–10%), forbs (1–10%), and shrubs (1–10%).

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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):** Not Present

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: Mid-statured, perennial bunchgrasses

    Sub-dominant: Rhizomatous grasses = perennial shortgrass ≥ 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. Shrub and subshrub mortality does not exceed 5% for any given species.

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14. **Average percent litter cover (%) and depth (in):** Total litter cover ranges from 15 to 30 percent. Litter is irregularly distributed on the soil surface and is often not at a measurable depth.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** Average annual production is 875. Low: 625 High 1050. 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:** Non-native invasive species on this ecological site include: dandelion (Taraxicum spp), cheatgrass (Bromus techtorum), field brome (Bromus arvensis), spotted knapweed (*Centaurea stoebe*), yellow toadflax (Linaria vulgaris), leafy spurge (*Euphorbia esula*)

    Native species with the ability to indicate degradation but species presence alone does not imply degradation include: Sandberg bluegrass (*Poa secunda*), big sagebrush (*Artemisia tridentata*), spineless horsebrush (Tetradymia canescens), broom snakeweed (*Gutierrezia sarothrae*), rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), Rocky Mountain juniper (Juniperus scopulorum),

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17. **Perennial plant reproductive capability:** Reproductive capability is very high. The density of plants indicates that plants reproduce at a level sufficient to fill available resources. There is no restriction on seed or vegetative reproductive capacity. Plants are producing seed and/or reproductive tillers.
