

# Ecological site EX044B01B040

## Loamy Steep (LoStp) LRU 01 Subset B

Last updated: 9/11/2023  
Accessed: 05/19/2024

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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. This MLRA borders two other MLRAs: 43B, Central Rocky Mountains and Foothills, and 46, Northern and Central Rocky Mountain Foothills.

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

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

MLRA 44B consists of one Land Resource Unit (LRU) and 7 Climate-based LRU subsets. Annual precipitation ranges from a low of 9 inches to a high of 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 edges of the MLRA, where it borders MLRA 43B. Frost-free periods also vary greatly, with less than 30 days in the Big Hole Valley to approximately 110 days in the warm valleys along the Yellowstone and Missouri Rivers.

MLRA 44B's plant communities are highly variable but are dominated by a cool-season grass and shrub-steppe community on the rangeland and a mixed coniferous forest in the mountains. Warm-season grasses occupy an extremely limited extent and number of species in this MLRA. Most subspecies of big sagebrush are present, to some extent, across the MLRA.

### LRU notes

LRU 01 Subset B Central Concept:

- Moisture Regime: Ustic, dry (bordering Aridic)
- Temperature Regime: Frigid
- Dominant Cover: rangeland (mixed grassland and sagebrush steppe)
- Representative Value (RV) of range of Effective Precipitation: 15-19 inches
- Representative Value (RV) of range of Frost Free Days: 90-110 days

Climate Subset B exists in primarily in the Madison, Gallatin, Meagher, and Park Counties.

### Classification relationships

Mueggler and Stewart. 1980. Grassland and Shrubland habitat types of Western Montana

1. *Artemisia tridentata*/Agropyron spicatum h.t.

2. *Agropyron spicatum*/*Agropyron smithii* h.t.
3. *Artemisia tridentata*/*Festuca scabrella* h.t.
4. *Agropyron spicatum*/*Bouteloua gracilis* h.t.

EPA Ecoregions of Montana, Second Edition:

Level I: Northwestern Forested Mountains

Level II: Western Cordillera

Level III: Middle Rockies & Northern Great Plains

Level IV: Paradise Valley

Townsend Basin

Dry Intermontane Sagebrush Valleys

Shield-Smith Valleys

National Hierarchical Framework of Ecological Units:

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

- Site does not receive any additional water
- Site greater than 15 percent slope
- Soils are
  - o Generally not saline or saline-sodic
  - o Moderately deep, deep, or very deep
  - o Soil surface texture ranges from loam to clay loam in surface mineral 4 inches
  - o Typically less than 5 percent stone and boulder cover (15 percent max)
  - o Not Skeletal ( less than 35 percent rock fragments) at 10-20 inch soil control section
  - o Not strongly or violently effervescent within surface mineral 4 inches
- Parent material is alluvium and residuum

### Associated sites

EX044B01B036	<b>Droughty (Dr) LRU 01 Subset B</b> EX044B01B036 Droughty Steep ecological site often occupies nearby sites.
EX044B01B032	<b>Loamy (Lo) LRU 01 Subset B</b> EX044B01B032 (Loamy) is often occupies similar landscape position and has a similar plant community. Slope is less than 15 percent

### Similar sites

EX044B01B036	<b>Droughty (Dr) LRU 01 Subset B</b> The Droughty Steep ecological site differs by being skeletal within 10-20 inch zone but have a similar state and transition model
EX044B01B032	<b>Loamy (Lo) LRU 01 Subset B</b> EX044B01B032 (Loamy) is often occupies similar landscape position and has a similar plant community. Slope is less than 15 percent and tends to express higher biomass production.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Artemisia tridentata</i> ssp. <i>wyomingensis</i> (2) <i>Tetradymia canescens</i>

Herbaceous	(1) <i>Festuca campestris</i> (2) <i>Pseudoroegneria spicata</i>
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## Legacy ID

R044BB040MT

## Physiographic features

This ecological site occurs on moderately steep to steep scarp slopes, hillslopes, and valley floors. This site exists on most aspects. This ecological site occurs on slopes ranging from 15 percent to 35 percent; however, the core slopes of this ecological site exist in the 15 percent to 25 percent range.

**Table 2. Representative physiographic features**

Landforms	(1) Intermontane basin > Scarp slope (2) Intermontane basin > Hillslope (3) Intermontane basin > Valley floor
Flooding frequency	None
Ponding frequency	None
Elevation	1,402–1,920 m
Slope	15–35%
Water table depth	254 cm
Aspect	Aspect is not a significant factor

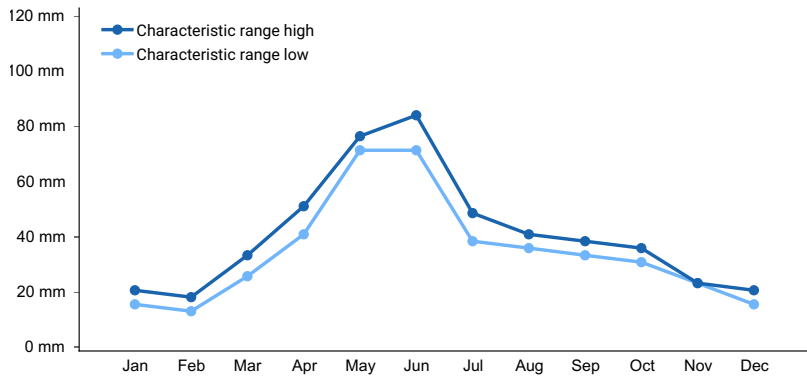
## Climatic features

The Central Rocky Mountain Valleys MLRA has a continental climate. 50 to 60 percent of the annual long-term average total precipitation falls between May and August. Most of the precipitation in the winter is snow on frozen ground. Average precipitation for LRU 01 Subset B is 17 inches, and the frost-free period averages 100 days. Precipitation is highest in May and June.

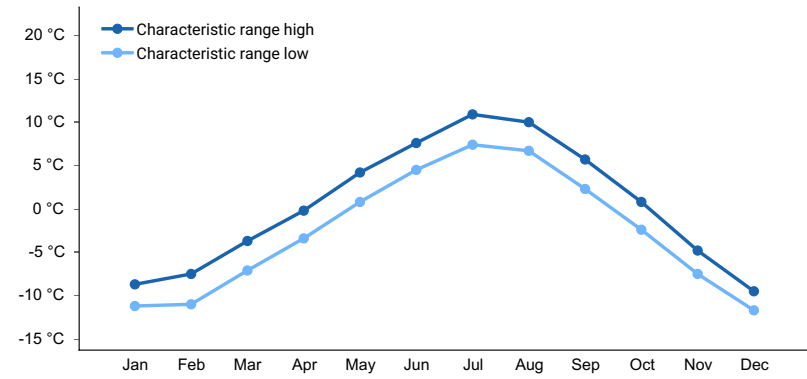
See Climatic Data Sheet for more details (Section II of the Field Office Technical Guide: [http://efotg.nrcs.usda.gov/efotg\\_locator.aspx?map=MT](http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=MT)) or reference the following climatic web site: <http://www.wrcc.dri.edu/climsum.html>

**Table 3. Representative climatic features**

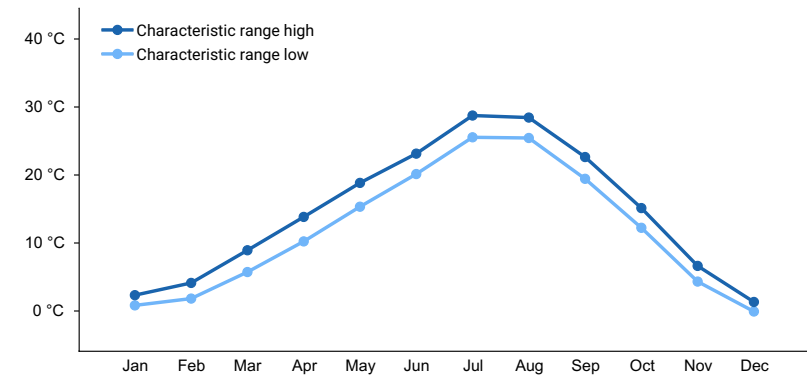
Frost-free period (characteristic range)	90-110 days
Freeze-free period (characteristic range)	96-123 days
Precipitation total (characteristic range)	356-483 mm
Frost-free period (actual range)	90-110 days
Freeze-free period (actual range)	82-136 days
Precipitation total (actual range)	356-483 mm
Frost-free period (average)	95 days
Freeze-free period (average)	108 days
Precipitation total (average)	432 mm



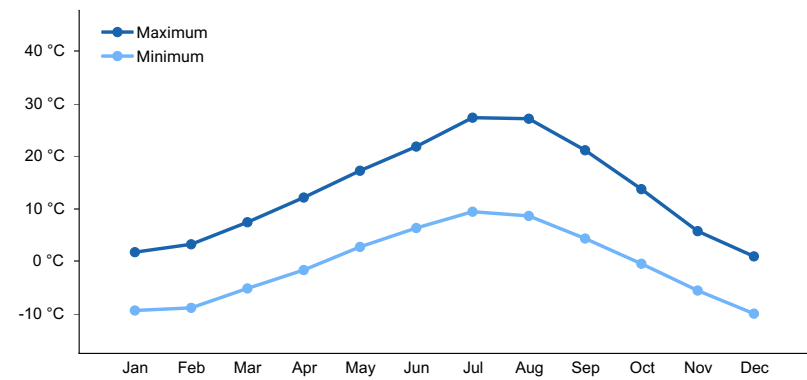
**Figure 1. Monthly precipitation range**



**Figure 2. Monthly minimum temperature range**



**Figure 3. Monthly maximum temperature range**



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

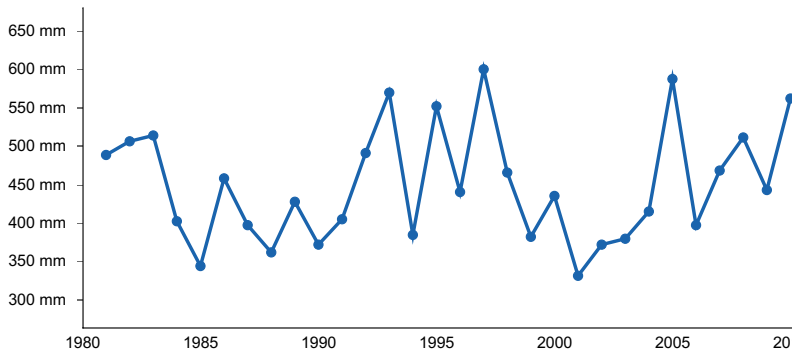


Figure 5. Annual precipitation pattern

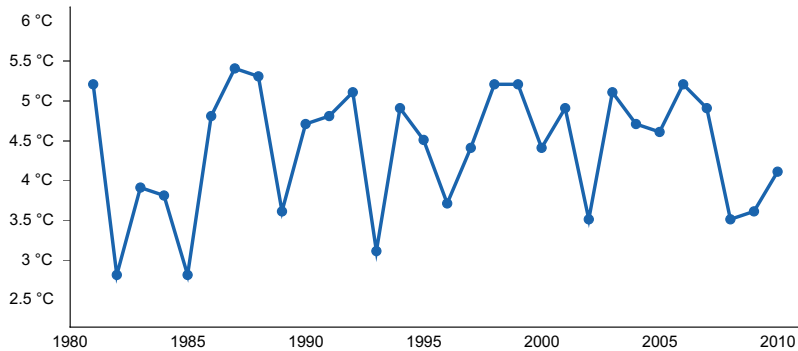


Figure 6. Annual average temperature pattern

### Climate stations used

- (1) WILSALL 8 ENE [USC00249023], Wilsall, MT
- (2) BOZEMAN 6 W EXP FARM [USC00241047], Bozeman, MT
- (3) NORRIS MADISON PH [USC00246157], Ennis, MT
- (4) MILLEGAN 14 SE [USC00245712], White Sulphur Springs, MT
- (5) LENNEP 5 SW [USC00244954], White Sulphur Springs, MT

### Influencing water features

The site is not associated with water features. The steep slopes associated with this ecological site may express increase surface runoff, particularly during high rainfall events associated with convective summer storms.

### Wetland description

Site is not associated with wetlands.

### Soil features

These soils are moderately deep to very deep, have moderately slow to moderately rapid permeability, and are well drained. These soils are formed from alluvium and residuum. Typically, soil surface textures consist of loam, silt loam, and clay loam textures. Clay content will be less than 32 percent in the surface mineral 4 inches (10cm) and, if present, an argillic horizon with less than 35 percent clay. Soils may have a gravelly surface; however, they will vary depending on their association with neighboring sites. Common soil series in this ecological site include Bacbuster, Reedwest, and Roundor.

Table 4. Representative soil features

Parent material	(1) Alluvium—sedimentary rock (2) Colluvium—sedimentary rock
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Surface texture	(1) Loam (2) Silt loam (3) Clay loam (4) Cobbly loam (5) Gravelly loam
Family particle size	(1) Fine-loamy
Drainage class	Moderately well drained to well drained
Permeability class	Slow to moderate
Soil depth	51–152 cm
Surface fragment cover <=3"	0–15%
Surface fragment cover >3"	0–10%
Available water capacity (0-101.6cm)	8.89–13.46 cm
Calcium carbonate equivalent (0-101.6cm)	0–10%
Electrical conductivity (0-101.6cm)	0–1 mmhos/cm
Soil reaction (1:1 water) (0-101.6cm)	6.4–7.8
Subsurface fragment volume <=3" (25.4-50.8cm)	0–18%
Subsurface fragment volume >3" (25.4-50.8cm)	0–15%

## Ecological dynamics

The reference plant community is dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*) and rough fescue (*Festuca campestris*). Subdominant species may include green needlegrass (*Nassella viridula*), Idaho fescue (*Festuca idahoensis*), needle and thread (*Hesperostipa comata*), Wyoming big sage (*Artemisia tridentata* ssp. *wyomingensis*), and winterfat (*Krascheninnikovia lanata*). This potential is suggested by investigations showing a predominance of perennial grasses on near-pristine range sites (Ross et al., 1973).

As the Loamy Steep ecological site in LRU 01 Subset B 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; under a drier moisture regime, it is often dominant, while under a colder, wetter regime, rough fescue may share dominance.

A shift to the dominance of shrubs may occur in response to improper grazing management, drought, or where big sagebrush occurs due to a lack of fire. Shrub encroachment by a variety of species, including broom snakeweed (*Gutierrezia sarothrae*), fringed sagewort (*Artemisia frigida*), Wyoming big sagebrush, rubber rabbitbrush (*Ericameria nauseosa*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), and plains prickly pear (*Opuntia polyacantha*), occurs within this site as the mid-statured 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 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 the nomadic nature and herd structure of bison, areas that were grazed received periodic, high-intensity, short-duration grazing pressure. Forage for livestock was noted as minimal in areas recently grazed by bison (Lesica and Cooper 1997). 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. In the 1890s, Montana sheep production began to increase (over 400 percent) and dominated the livestock industry until the 1930s. Since the 1930s, cattle production has dominated the livestock

industry in the region (Wyckoff and Hansen 2001).

Natural fire was a major ecological driver of this entire ecological site. Fire tended to restrict tree and sagebrush growth to small patches and promote an herbaceous plant community. The natural fire return interval was highly variable, ranging up to 100 years; however, it was likely shorter than 35 years (Arno and Gruell 1983). With the historically recent, since 1910, suppression of fire sagebrush and trees has increased significantly.

The potential for dryland farming is relatively low due to the slope and risk of water erosion; however, the neutral to slightly alkaline pH and relatively high soil organic matter of the soils allow for production agriculture. Hay and small grain production have constituted the largest replacement of native vegetation on this site, with introduced cool-season annual crops (wheat, barley, and oats), perennial introduced grass species, and legumes (e.g., alfalfa) being best adapted. This ecological site has also been converted to pastureland, usually with perennial grasses and legumes for grazing. Cropland, pastureland, and hayland are intensively managed with annual cultivation, annual harvesting, and/or frequent use of herbicides, pesticides, and commercial fertilizers to increase production. Where irrigation water is available, this site is highly productive.

Some of the major invasive species that can occur on this site include (but are not limited to) spotted knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*), sulphur cinquefoil (*Potentilla recta*), cheatgrass (*Bromus tectorum*), field brome (*Bromus arevensis*), yellow toadflax (*Linaria vulgaris*), dandelion (*Taraxicum* species), Kentucky bluegrass (*Poa pratensis*), and smooth brome (*Bromus inermis*). Invasive weeds are beginning to have a high impact on this ecological site due to primarily human impacts from mismanaged grazing and urban development.

#### 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.

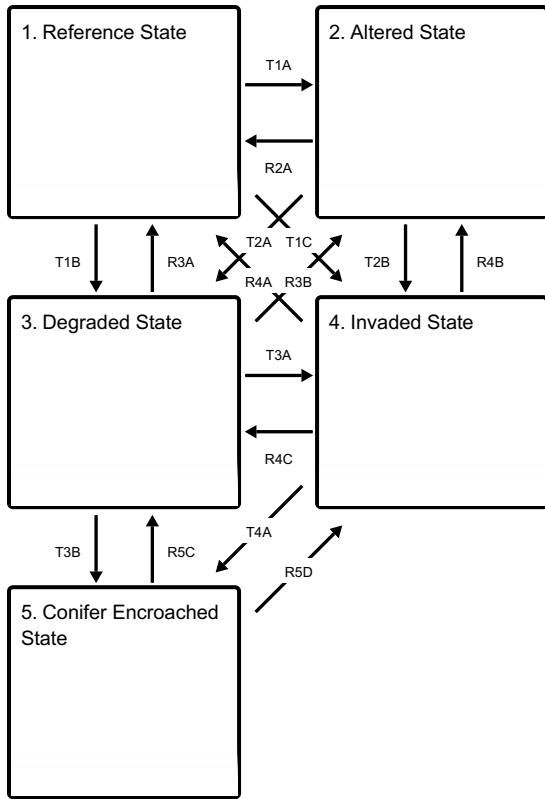
Both percent species composition by weight and percent canopy cover are referenced in this document. Canopy cover drives the transitions between communities and states because of the influence of shade, the interception of rainfall, and the competition for available water. Species composition by dry 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.

This state and transition model (STM) includes only rangeland communities and states. The converted communities are described in the Ecological Dynamics of the Site section above.

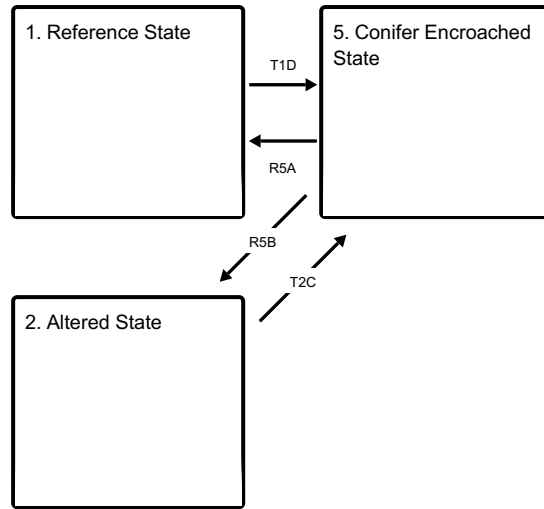
Although there is considerable qualitative experience supporting the pathways and transitions within the STM, no quantitative information exists that specifically identifies threshold parameters between grassland types and invaded types in this ecological site. For information on STMs, see the following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

#### State and transition model

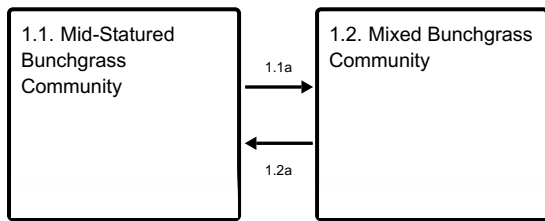
**Ecosystem states**



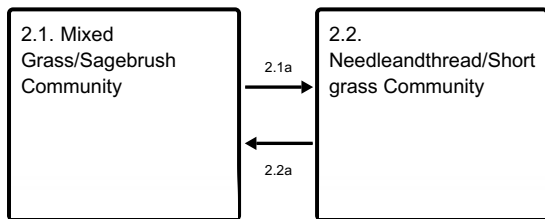
**States 1, 5 and 2 (additional transitions)**



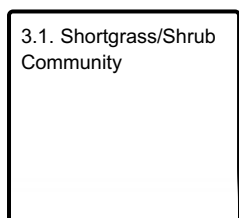
**State 1 submodel, plant communities**



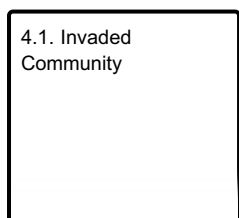
**State 2 submodel, plant communities**



**State 3 submodel, plant communities**



**State 4 submodel, plant communities**





State 5 submodel, plant communities

5.1. Conifer  
Encroached  
Community

State 1  
Reference State

The Reference State of this ecological site consists of two (2) known potential plant communities: the Mid-Staturred Bunchgrass Community and the Mixed Bunchgrass 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 rough fescue, bluebunch wheatgrass, and green needlegrass. This community is considered the reference, while Community 1.2 is primarily bluebunch and needle and thread with rough fescue and Wyoming big sagebrush.

Community 1.1  
Mid-Staturred Bunchgrass Community

In this Reference Plant Community, rough fescue (*Festuca scabrella*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and green needlegrass (*Nassella viridula*), are typically dominant. Basin wildrye, Idaho fescue, and needle and thread will be subordinates. Shrub species (big sagebrush, fringed sagewort, and broom snakeweed) remain a minor part of the community. Spineless horsebrush (*Tetradymia canescens*) and antelope bitterbrush (*Purshia tridentata*) may occupy a small niche. Sandberg bluegrass (*Poa secunda*) and dryland sedges may also be present. This community occurs on this Loamy Steep site in areas with proper livestock grazing or in areas with little or no grazing pressure. Bluebunch wheatgrass lacks resistance to grazing during the critical growing season (spring) and will decline in vigor and production if grazed in the critical growing season more than one year in three (Wilson et al. 1960). This community is moderately resilient and will return to dynamic equilibrium following a relatively short period of stress (such as drought or short-term improper grazing), provided a return of favorable or normal growing conditions, and properly managed grazing. As discussed in the Ecological Dynamics section, the natural fire regime restricted shrubs to relatively small portions of the Mid-Staturred Bunchgrass Community 1.1. Shrub species present may include Wyoming big sagebrush, silver sagebrush, winterfat, tarragon (*Artemisia drucunculus*), and fringed sagewort. Infrequent fire probably maintained sagebrush communities as open, seral stands of productive herbaceous species with patches of big sagebrush.

**Resilience management.** Prescribed Grazing, Prescribed Burning, Brush Management, Pest Management

Dominant plant species

- big sagebrush (*Artemisia tridentata*), shrub
- winterfat (*Krascheninnikovia lanata*), shrub
- spineless horsebrush (*Tetradymia canescens*), shrub
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass
- green needlegrass (*Nassella viridula*), grass
- rough fescue (*Festuca campestris*), grass
- needle and thread (*Hesperostipa comata*), grass

Table 5. Annual production by plant type

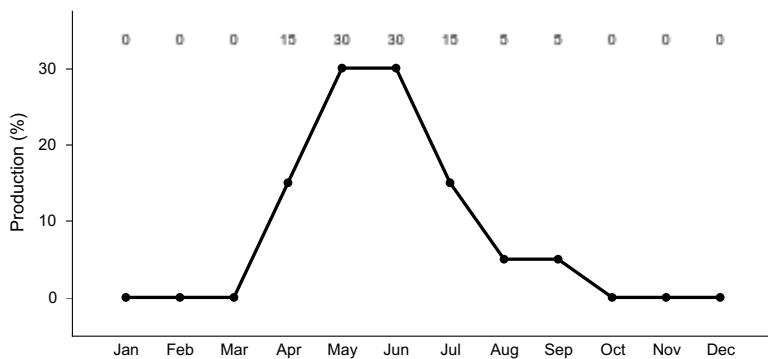
Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1194	1485	1771
Shrub/Vine	123	193	252
Forb	22	45	56
<b>Total</b>	<b>1339</b>	<b>1723</b>	<b>2079</b>

**Table 6. Ground cover**

Tree foliar cover	0%
Shrub/vine/liana foliar cover	3-5%
Grass/grasslike foliar cover	10-15%
Forb foliar cover	1-5%
Non-vascular plants	0-1%
Biological crusts	3-5%
Litter	35-45%
Surface fragments >0.25" and <=3"	0-15%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	10-15%

**Table 7. Soil surface cover**

Tree basal cover	0%
Shrub/vine/liana basal cover	1-5%
Grass/grasslike basal cover	10-15%
Forb basal cover	3-5%
Non-vascular plants	0-1%
Biological crusts	0-5%
Litter	35-45%
Surface fragments >0.25" and <=3"	0-10%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	10-15%



**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 and Idaho fescue tolerate grazing pressure better than bluebunch wheatgrass, rough fescue,

and green needlegrass. The growing point for bluebunch wheatgrass and rough fescue is several inches above the ground, making them very susceptible to continued close grazing (Smoliack, et al 2006), while needle-and-thread and Idaho fescue growing points tend to be near the plant base. These grasses increase in species composition when more palatable and less grazing tolerant plants decrease due to improper grazing management. Idaho fescue, needle-and-thread, and bluebunch wheatgrass share dominance in the Mixed Bunchgrass Community (1.2). Rough fescue is reduced to be a subordinate component of the community. Other grass species, which are more tolerant to grazing and are likely to increase compared to the Mid-statured Bunchgrass Community, include Sandberg bluegrass (*Poa secunda*), prairie Junegrass, and western/thickspike wheatgrass (*Pascopyrum smithii*, *Elymus lanceolatus*) and blue grama (*Bouteloua gracilis*). Some increaser forb species include western yarrow, Hoods phlox (*Phlox hoodii*), Scarlet globemallow (*Sphaeralcea coccinea*), hairy goldenaster (*Heterotheca villosa*), and pussytoes (*Antennaria* spp.). Fringed sagewort may 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. Timing of grazing is important on this site because of the moisture limitations beyond June, especially on the drier sites. Bare ground will increase and expose the soil to erosion. Litter and mulch will be reduced as plant cover declines. As long as the production of bluebunch wheatgrass and rough fescue are still a dominant species of total biomass production, the site can return to the Mid-statured Bunchgrass Community (Pathway 1.2A) under proper grazing management and favorable growing conditions. Needle-and-thread and western wheatgrass will continue to increase until they make up the majority of species composition. Once bluebunch wheatgrass has been reduced to less than 30 percent dry weight, it may be difficult for the site to recover to Mid-statured Bunchgrass Community (1.1). The risk of soil erosion increases when canopy cover decreases. As soil conditions degrade, there will be loss of organic matter, reduced litter, and reduced soil fertility. Degraded soil conditions increase the difficulty of reestablishing bluebunch wheatgrass and rough fescue preventing the return to the Mid-statured Bunchgrass Community (1.1). The Mixed Bunchgrass Community (1.2) is considered 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 State (2) or the Degraded 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 Mid-statured Bunchgrass Community (1.1) using prescribed grazing and strategic weed control. It may take several years to achieve this recovery, depending on growing conditions, vigor of remnant bluebunch wheatgrass plants, and the aggressiveness of the weed treatments.

**Resilience management.** prescribed grazing, brush management, pest management, prescribed fire

### **Dominant plant species**

- big sagebrush (*Artemisia tridentata*), shrub
- winterfat (*Krascheninnikovia lanata*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- yellow rabbitbrush (*Chrysothamnus viscidiflorus*), shrub
- Idaho fescue (*Festuca idahoensis*), grass
- needle and thread (*Hesperostipa comata*), grass
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass

### **Pathway 1.1a**

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

Mid-statured bunchgrasses lose vigor with improper grazing or extended drought. When vigor declines enough for plants to die or become smaller, species with higher grazing tolerance (in this Ecological Site that would be Idaho fescue and needle-and-thread) increase in vigor and production as they access the resources previously used by rough fescue and bluebunch wheatgrass. Decrease of these two species to less than 50 percent composition 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 rough fescue and 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 in a critical stage of development earlier than expected. Since needle-and-thread normally heads out in June and bluebunch wheatgrass in July this should be taken into consideration when planning grazing management.

## Pathway 1.2a

### Community 1.2 to 1.1

The Mixed Bunchgrass Community (1.2) will return to the Mid-Statured 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 bluebunch dominated state. The driver for this community shift (1.2a) is increased vigor of midstatured, decrease in bunchgrasses to the point that it represents more than 50 percent of species composition. The trigger for this shift is the change in grazing management favoring bluebunch wheatgrass. In general, conservative grazing management styles such as deferred or rest rotations utilizing moderate grazing (less than 50 percent 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 bluebunch wheatgrass 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.

#### Conservation practices

Prescribed Burning
Prescribed Grazing

## State 2

### Altered State

This state is characterized by having less than 20 percent rough fescue and bluebunch wheatgrass by dry weight. It is represented by two (2) 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/or heavy grazing practices. A few of these species may include Idaho fescue, needle and thread, Sandberg bluegrass, scarlet globemallow, hairy goldenaster, and fringed sagewort.

**Characteristics and indicators.** Less than 20 percent bluebunch wheatgrass & rough fescue  
Increase in short stature grasses  
Increase in bare ground

**Resilience management.** Conservative grazing management, Integrated Pest Management, time

#### Dominant plant species

- big sagebrush (*Artemisia tridentata*), shrub
- yellow rabbitbrush (*Chrysothamnus viscidiflorus*), shrub
- broom snakeweed (*Gutierrezia sarothrae*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- needle and thread (*Hesperostipa comata*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- prairie Junegrass (*Koeleria macrantha*), grass
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass

## Community 2.1

### Mixed Grass/Sagebrush Community

Long-term grazing mismanagement with continuous growing-season pressure will reduce total productivity of the site and lead to an increase of bare ground. Suppression of fire can also promote shrub growth, increasing plant interspaces. 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 State (2), because it creates a threshold requiring input of energy to return to the Reference State (1). Transition to the Mixed Grass/Sagebrush Community (2.1) may be exacerbated by extended drought conditions. Needle-and-thread and Idaho fescue dominate this Mixed Grass/Sagebrush Community (2.1). Bluebunch wheatgrass and rough fescue make up less than 30 percent of species composition by

dry weight and the remaining mid-statured bunchgrasses plants tend to be scattered and low in vigor. Increaser and invader species will be more common. Increaser forb species include hairy goldenaster, Missouri goldenrod, stonecrop, lupine, and yarrow. It is not uncommon for a minor component of invader species such as dandelion and goatsbeard to be present. This creates more competition for bluebunch wheatgrass and rough fescue making it difficult for them 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). 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). Winterfat is tolerant of low intensity fire but will kill with a hot fire (Pellant 1984). 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 (1) will require reclamation efforts, i.e., soil rebuilding, intensive mechanical treatments, and/or reseeding. The transition to this state could result from overgrazing and fire suppression, especially repeated early season grazing coupled with 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 and mulch will move off-site as plant cover declines. The Mixed Grass/Sagebrush Community will then shift to a Needle-and-thread/Shortgrass Community (2.2). Continued improper grazing will drive the community to a Degraded State (3). Introduction or expansion of invasive species will further drive the plant community to the Invaded State (4).

### **Dominant plant species**

- big sagebrush (*Artemisia tridentata*), shrub
- yellow rabbitbrush (*Chrysothamnus viscidiflorus*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- broom snakeweed (*Gutierrezia sarothrae*), shrub
- needle and thread (*Hesperostipa comata*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass
- prairie Junegrass (*Koeleria macrantha*), grass

## **Community 2.2**

### **Needleandthread/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, shorter rooted species will become co-dominant with the bunchgrasses. Shrubs will become more competitive for limited moisture as bare ground and soil erosion increase. This state may exhibit conditions where livestock is consuming shrubs.

### **Dominant plant species**

- broom snakeweed (*Gutierrezia sarothrae*), shrub
- yellow rabbitbrush (*Chrysothamnus viscidiflorus*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- big sagebrush (*Artemisia tridentata*), shrub
- needle and thread (*Hesperostipa comata*), grass
- Sandberg bluegrass (*Poa secunda*), grass
- prairie Junegrass (*Koeleria macrantha*), grass

- bluebunch wheatgrass (*Pseudoroegneria spicata*), grass

## 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 continued loss of bunchgrass vigor, especially bluebunch and rough fescue. The short-statured grasses will become more competitive and become co-dominant with the bunchgrasses. Shrubs will increase in canopy cover however may be browsed resulting in spreading formations.

## 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 Mixed Grass/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 Mixed Grass/Sagebrush Community 2.1 to Plant 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 heavy to moderate utilization (less than 50 percent). Strategic shrub removal and favorable growing conditions may 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. Caution must be used to not completely remove sagebrush as it does remain an important component of the entire ecological site.

### Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

## State 3

### Degraded State

Degraded State lacks midstatured bunchgrasses. Sandberg bluegrass, western wheatgrass, and prairie Junegrass are dominant grasses, while increaser shrubs nearly replace larger shrub species. Remaining larger shrub species are heavily hedged. This is very likely a terminal state (e.g., restoration will likely be impossible or unsuccessful and require major energy inputs to be marginally successful).

**Characteristics and indicators.** 25 percent increase in bare ground over the Reference State. annual grasses common complete removal of bluebunch wheatgrass & rough fescue and replaced with sandberg bluegrass, western wheatgrass, and blue grama sagebrush nearly gone and replaced with rabbitbrush and broom snakeweed

**Resilience management.** Prescribed grazing, Range seeding, Brush Management, Integrated Pest Management

### Dominant plant species

- broom snakeweed (*Gutierrezia sarothrae*), shrub
- yellow rabbitbrush (*Chrysothamnus viscidiflorus*), shrub
- rubber rabbitbrush (*Ericameria nauseosa*), shrub
- plains pricklypear (*Opuntia polyacantha*), shrub
- Sandberg bluegrass (*Poa secunda*), grass
- blue grama (*Bouteloua gracilis*), grass
- prairie Junegrass (*Koeleria macrantha*), grass
- sixweeks fescue (*Vulpia octoflora*), grass
- needle and thread (*Hesperostipa comata*), grass

## **Community 3.1**

### **Shortgrass/Shrub Community**

Soil loss continues or increases to the point that native perennial grasses make up less than half of the annual dry weight production. Grass and forb cover may be very sparse or clumped. Weeds, annual species, cacti, or shrubs dominate the plant community. Increaser perennial bunchgrass species (e.g., needle-and-thread) exist as small clumps with only basal leaves. This could occur due to overgrazing (failure to adjust stocking rate to declining forage production due to increased invasive dominance), long-term lack of fire (if Wyoming Big Sagebrush occurs), or 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. Large patches of prickly pear cactus are common. 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 lack of organic matter deposition due to sparse vegetation create 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 25 percent. In this plant community, big sagebrush is replaced with a dominant community of broom snakeweed, rabbitbrush, fringed sagewort, and plains pricklypear cactus. This state has lost soil and vegetation attributes to the point that recovery to the Reference State will require reclamation efforts, i.e. 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 State**

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.

**Characteristics and indicators.** High amounts of invading species (both native and introduced).

**Resilience management.** Integrated Pest Management Prescribed Grazing Brush Management Prescribed Fire Range Seeding

## **Community 4.1**

### **Invaded Community**

Communities in this state may be structurally indistinguishable from the Reference State except that invasive/noxious species exceed 20 percent of species composition by dry weight. This state may also include a community similar to the Degraded State (3) except that invasive/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 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 Kentucky bluegrass or spotted knapweed, where soil fertility and chemistry remain near reference, 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. Dense clubmoss has been included in this community until more information has been collected on its relationship with the Loamy Ecological Site. Since dense clubmoss is a portion of the reference plant community, it will only be considered as part of the

invaded community when it significantly impacts plant production. The exact percent cover clubmoss at which it affects overall production has not been fully studied in this MLRA. 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 placed in preventing plant communities from crossing a threshold to 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).

## **State 5**

### **Conifer Encroached State**

Rocky Mountain juniper (*Juniperus scopulorum*), Douglas fir (*Pseudotsuga menziesii*), and ponderosa pine (*Pinus ponderosa*) encroachment is limited on this ecological site and is generally focused in areas where the mountains of MLRA 44B transition quickly to MLRA 43B. Under the Reference State, no conifers should exist on this site. Conifer Encroached State consists of up to 4 potential phases. The Early Phase, Mid Phase, Late Phase, and Closed Phase are defined by the amount of encroachment and age class of the stand. This state typically occurs in response to a combination of long-term fire suppression, grazing history, and increased atmospheric carbon dioxide. The trigger for transition is a coniferous expansion of more than 2 stems per acre.

## **Community 5.1**

### **Conifer Encroached Community**

Rocky Mountain juniper (*Juniperus scopulorum*), Douglas fir (*Pseudotsuga menziesii*), and/or Ponderosa pine (*Pinus ponderosa*) encroachment is limited on this ecological site and is generally focused in areas where the mountains of MLRA 44B transition quickly to MLRA 43B. Under the Reference State, no conifers should exist on this site. Conifer encroachment likely occurs in the late stages of the Altered State (see State-and-transition model) where there is an increase of bare ground due to a combination of factors. Fire suppression and improper grazing management are the two most common triggers. The exact conditions in which juniper begins to encroach vary however the trend points to a combination of 1 or more of the following: moderately heavy to heavy grazing, reduced (non-existent) fire frequency, increased atmospheric carbon, and generally warmer climate (compared to that of pre-settlement). When heavy grazing occurs areas in the plant canopy open allowing for seed dispersal by bird or overland flow via rills on neighboring sites. The effects of juniper encroachment are not immediately noticed however over time as juniper canopy increases; light and water interception increase which reduce opportunities for herbaceous plants. One paper (Barrett, 2007) suggests that for precipitation to penetrate the juniper canopy, events must be greater than 0.30 inches. Increase juniper canopy creates perching sites for predators which reduces site suitability for greater sage grouse. More information is needed on the full extent and impact of conifer encroachment on this plant communities for an approved Ecological Site Description. Studies (Miller et al 2000) based in a similar community to the Rocky Mountain Juniper community of Montana suggest following a phased approach to characterize the juniper stand. Not unlike the Western Juniper community discussed in Miller et al, the Rocky Mountain juniper communities of Montana exhibit 3 or 4 different phases based, at this time, on unquantified information. Phase I (Early) is defined by actively expanding juniper cover with generally less than 10 percent canopy cover and the trees' limbs generally touch the ground. This early stage generally has not lost its hydrologic functions however herbaceous plant communities may show signs of reduced production and species richness. Control methods include mechanical removal and prescribed fire. Prescribed fire is still effective in this phase as it still contains the necessary native plants for recovery. The tree canopy is also low enough that risk of a dangerously hot fire is reduced. Phase II (Mid Stage) is still actively expanding however canopy cover may reach up to 25 percent and due to the more mature trees seed production is very high. This Mid Phase begins to highly restrict herbaceous and shrubby plant and junipers tend to be codominant. Hydrology is departing from reference with rills becoming longer and in isolated areas erosional gullies may exist. Control methods of the Mid Stage should focus on mechanical treatment as there is a high risk of catastrophic and potentially sterilizing fire. Phase III (Late stage) is where juniper cover exceed 25 percent and has slowed as a forest condition. Lower limbs of trees begin to die and the shrub cover is nearly lost. Traveling through this community is increasingly difficult. Junipers become the dominant plant with herbaceous plant production greatly decreased. Bare ground increases and hydrologic function is nearly lost compared to a grass/shrub community. Late Stage Phase should focus more on restoration than control as the necessary plants will likely not be present to cross the threshold back to a rangeland situation. The



soil stability and hydrologic function are lacking in this phase so mechanical removal of juniper will be necessary. Phase IV (Closed) is the steady state forest where the system is nearly absent of rangeland plants. The trees stop producing seed and begin to close in on each other. This phase is impassible and nearly all light and precipitation are intercepted. Bare ground is high and soil chemistry slowly changes due to acidification from juniper. Within this LRU, the closed phase is extremely rare due to 2 reasons: 1) this phase takes upwards of 100 years to occur 2) management often occurs before trees are allowed to reach this phase. The presence of sagebrush stumps indicates the historical plant community as rangeland which will prevent misclassification of historic Juniper Forests (often greater than 100 years of age).

## **Transition T1A**

### **State 1 to 2**

The Reference State (1) transitions to the Altered State (2) if bluebunch wheatgrass and rough fescue, by dry weight, decreases to below 30 percent or if bare ground cover is increases by 10 percent. The driver for this transition is loss of taller bunchgrasses, which creates open areas in the plant canopy with bare soil. Soil erosion results in decreased soil fertility, driving transitions to the Altered 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 trigger for this transition is improper grazing management and/or long-term drought leading to a decrease in bluebunch wheatgrass and rough fescue composition to less than 30 percent and reduction in total plant canopy cover.

### **Conservation practices**

Brush Management
Prescribed Burning
Prescribed Grazing

## **Transition T1B**

### **State 1 to 3**

The Reference State (1) transitions to the Degraded State (3) when bluebunch wheatgrass and rough fescue are removed from the plant community and Needle-and-thread is subdominant to short statured bunchgrasses such as Sandberg bluegrass. The trigger for this transition is loss of taller bunchgrasses, which creates open spaces with bare soil. Soil erosion results in decreased soil fertility, driving transitions to the Degraded 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, intense or repeated fires, and/or heavy human disturbance. Rapid transition is generally realized where livestock are confined to small pastures for long periods of time.

## **Transition T1C**

### **State 1 to 4**

Healthy plant communities are most resistant to invasion however, regardless of grazing management, without some form of active weed management (chemical, mechanical, or biological control) and without prevention the Reference State (1) can transition to the Invaded State (4) in the presence of aggressive invasive species such as spotted knapweed, leafy spurge, and cheatgrass. The Central Rocky Mountain Valleys tend to resist invasion of cheatgrass however repeated heavy grazing or intense human activities can open the interspaces of the bunchgrass community and allow for encroachment. 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 trigger for this transition is the presence of aggressive invasive species. Species composition by dry weight of invasive species approaches 10 percent.

## **Transition T1D**

### **State 1 to 5**

Canopy cover of conifer tree/shrub cover exceeds 1 stem per acre. The trigger is the presence of seeds and/or other viable material of invasive species.

## **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. Examples of mechanical treatment may be brush control while cultural treatments may include prescribed grazing, targeted brush browsing, or prescribed burning. Low intensity prescribed fires to reduce competitive increaser plants such as needle-and-thread and Sandberg bluegrass. A low intensity fire will also reduce Wyoming big sagebrush densities. In areas with potential of annual grass infestation, fire should be carefully planned or avoided. The drivers for this restoration pathway are reclamation efforts along with proper grazing management.

### **Conservation practices**

Brush Management
Prescribed Burning
Fence
Livestock Pipeline
Grazing Land Mechanical Treatment
Range Planting
Prescribed Grazing

## **Transition T2A**

### **State 2 to 3**

As improper grazing management continues vigor of bunch grasses will decrease, and the shorter grasses and shrubs will increase towards the Degraded State (3). Prolonged drought will provide a competitive advantage to shrubs allowing them to become co-dominant with grasses. Shrub canopy will increase. Key transition factors: increase of native shrub canopy cover; reduction in bunchgrass production; decrease in total plant canopy cover and production; 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.

## **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 20 percent dry weight of invasive species. The trigger is the presence of seeds and/or other viable material of invasive species.

## **Transition T2C**

### **State 2 to 5**

Canopy cover of conifer tree/shrub cover exceeds 1 stem per acre. The trigger is the presence of seeds and/or other viable material of invasive species.

## **Restoration pathway R3A**

### **State 3 to 1**

The Degraded 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. Studies suggest (Whitford et al 1989) a mulch with high carbon to nitrogen ratio such as wood chips or bark in low moisture

scenarios can be beneficial for slow mobilization of plant available nitrogen. Biochar may also be added to the system to improve Soil Organic Carbon (SOC) which should improve Cation Exchange Capacity (CEC), microbial activity, and hydrologic conductivity (Stavi 2012). The drivers for the restoration pathway are 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 presence of seeds and/or other viable material in the soil and management related increases soil disturbance.

#### Conservation practices

Brush Management
Prescribed Burning
Fence
Grazing Land Mechanical Treatment
Range Planting
Prescribed Grazing

### Restoration pathway R3B 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 a sufficient amount of grass remains on the site, chemical application and/or biological control in conjunction with proper grazing management, can reduce the amount of shrubs and invasive species and restore the site to the 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 re-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
Prescribed Burning
Range Planting
Integrated Pest Management (IPM)
Prescribed Grazing

### Transition T3A State 3 to 4

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

### Transition T3B State 3 to 5

Canopy cover of conifer tree/shrub cover exceeds 1 stem per acre. The trigger is the presence of seeds and/or other viable material of invasive species.

## Restoration pathway R4A 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 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. If invaded by conifer encroachment, treatment depends on the condition of the rangeland. See Plant community 4.1 for alternative measures of restoration. Sites that have transitioned from the Degraded State (3) to the Invaded State (4) may be severely lacking soil and vegetative properties that will allow for restoration to the Reference State. Hydrologic function damage may be irreversible especially with accelerated gully erosion.

### Conservation practices

Brush Management
Prescribed Burning
Range Planting
Integrated Pest Management (IPM)
Rangeland Fertilization
Prescribed Grazing

## Restoration pathway R4B State 4 to 2

If invasive species are removed before remnant populations of bunchgrasses have been drastically reduced the Invaded State (4) can return to the 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.

### Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

## Restoration pathway R4C State 4 to 3

If invasive species are removed the site could return to the Degraded State (3). Without sufficient remnant populations of preferred plants the Invaded State (4) is not likely to return to any of the other states. The driver for the reclamation pathway is weed management without reseeding. The trigger is invasive species control. The invading species cause a significant increased soil loss due to lack of ground cover (Lacey et al. 1989).

### Conservation practices

Brush Management
Prescribed Burning
Integrated Pest Management (IPM)
Prescribed Grazing

## Transition T4A State 4 to 5

Canopy cover of conifer tree/shrub cover exceeds 1 stem per acre. The trigger is the presence of seeds and/or other viable material of invasive species.

## **Restoration pathway R5A**

### **State 5 to 1**

Depending on the level of conifer canopy cover and its impact on rangeland health, restoration efforts may be simply focus on removal of coniferous trees and shrubs to restore the Conifer Encroached State (5) to the Reference State (1). If utilizing the phases established by Miller et al management and restoration methods will vary. An large majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's Phases. Phase I may exhibit None-Slight to Moderate departures from rangeland health where removal of the conifers via Brush Management and/or Prescribed fire combined. If mechanical removal of conifers is utilized, no grazing management is needed assuming relatively conservative management had been used prior to treatment. If prescribed fire is utilized, short term grazing deferment and/or rest is suggested. Given a short time removal of a Phase I encroachment will recover to Reference. Proactive pest management is encouraged. Phase II Encroachment may require a more intense mechanical removal of trees/shrubs with Prescribed Fire not being a feasible method of control as this community may be at risk of catastrophic fire due to canopy density. Phase II displays a Moderate departure from Reference suggesting an overall instability of the site such as reduced herbaceous production, reduced functional/structural groups (e.g. reduced mid-statured bunchgrasses), increase rill frequency and length, and possibly increased bare ground. Increased post treatment grazing management may be necessary. Grazing management may be as simple as short term growing season deferment however long term rest may be necessary in the latter stages of Phase II encroachment. Latter stages of Phase II encroachment will likely require some short term erosion mitigation such as straw wattles as well as range planting and/or critical area planting to re-establish any loss of native herbaceous plants particularly mid-statured cool season bunchgrasses. Phase III Encroachment canopy cover resembles forested sites with larger trees and shrubs. Forest management style tree removal (woody debris and logs removed from the site) will be necessary prior to any prescribed burning as to prevent the fire from burning too hot. The result of a prescribed fire on this site are typically unknown as seed sources of native herbaceous plants are usually limited to small patches. Since herbaceous plants will likely have been depleted under a Phase III encroachment, there is an opportunity for large areas of bare ground, increase rill and in some cases gully erosion. Post treatment will require range planting and/or critical area seeding, erosion control, pest management, and possibly soil carbon amendments (biochar). Grazing management (primarily rest) will be necessary to ensure any new seedling establishment.

## **Restoration pathway R5B**

### **State 5 to 2**

The Conifer Encroached State (5) Phases I and II will generally resemble the Altered State (2) on this site. If utilizing the phases established by Miller et al management and restoration methods will vary. An large majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's Phases. Phase I may exhibit None-Slight to Moderate departures from rangeland health where removal of the conifers via Brush Management and/or Prescribed fire combined. If mechanical removal of conifers is utilized, no grazing management is needed assuming relatively conservative management had been used prior to treatment. If prescribed fire is utilized, short term grazing deferment and/or rest is suggested. Given a short time removal of a Phase I encroachment will recover to Reference. Proactive pest management is encouraged. Phase II Encroachment may require a more intense mechanical removal of trees/shrubs with Prescribed Fire not being a feasible method of control as this community may be at risk of catastrophic fire due to canopy density. Phase II displays a Moderate departure from Reference suggesting an overall instability of the site such as reduced herbaceous production, reduced functional/structural groups (e.g. reduced mid-statured bunchgrasses), increase rill frequency and length, and possibly increased bare ground. Increased post treatment grazing management may be necessary. Grazing management may be as simple as short term growing season deferment however long term rest may be necessary in the latter stages of Phase II encroachment. Latter stages of Phase II encroachment will likely require some short term erosion mitigation such as straw wattles as well as range planting and/or critical area planting to re-establish any loss of native herbaceous plants particularly mid-statured cool season bunchgrasses. Phase III Encroachment canopy cover resembles forested sites with larger trees and shrubs. Forest management style tree removal (woody debris and logs removed from the site) will be necessary prior to any prescribed burning as to prevent the fire from burning too hot. The result of a prescribed fire on this site are typically unknown as seed sources of native herbaceous plants are usually limited to small patches. Since herbaceous plants will likely have been depleted

under a Phase III encroachment, there is an opportunity for large areas of bare ground, increase rill and in some cases gully erosion. Post treatment will require range planting and/or critical area seeding, erosion control, pest management, and possibly soil carbon amendments (biochar). Grazing management (primarily rest) will be necessary to ensure any new seedling establishment.

## **Restoration pathway R5C**

### **State 5 to 3**

The Conifer Encroached State (5) Phases II and III will likely resemble the Degraded State (3) on this site due to reduced midstatured bunchgrasses. If utilizing the phases established by Miller et al management and restoration methods will vary. An large majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's Phases. This Restoration Pathway is exceedingly rare as it is typically not cost effect for land managers to manage for a degraded state. Phase I may exhibit None-Slight to Moderate departures from rangeland health where removal of the conifers via Brush Management and/or Prescribed fire combined. If mechanical removal of conifers is utilized, no grazing management is needed assuming relatively conservative management had been used prior to treatment. If prescribed fire is utilized, short term grazing deferment and/or rest is suggested. Given a short time removal of a Phase I encroachment will recover to Reference. Proactive pest management is encouraged. Phase II Encroachment may require a more intense mechanical removal of trees/shrubs with Prescribed Fire not being a feasible method of control as this community may be at risk of catastrophic fire due to canopy density. Phase II displays a Moderate departure from Reference suggesting an overall instability of the site such as reduced herbaceous production, reduced functional/structural groups (e.g. reduced mid-statured bunchgrasses), increase rill frequency and length, and possibly increased bare ground. Increased post treatment grazing management may be necessary. Grazing management may be as simple as short term growing season deferment however long term rest may be necessary in the latter stages of Phase II encroachment. Latter stages of Phase II encroachment will likely require some short term erosion mitigation such as straw waddles as well as range planting and/or critical area planting to re-establish any loss of native herbaceous plants particularly mid-statured cool season bunchgrasses. Phase III Encroachment canopy cover resembles forested sites with larger trees and shrubs. Forest management style tree removal (woody debris and logs removed from the site) will be necessary prior to any prescribed burning as to prevent the fire from burning too hot. The result of a prescribed fire on this site are typically unknown as seed sources of native herbaceous plants are usually limited to small patches. Since herbaceous plants will likely have been depleted under a Phase III encroachment, there is an opportunity for large areas of bare ground, increase rill and in some cases gully erosion. Post treatment will require range planting and/or critical area seeding, erosion control, pest management, and possibly soil carbon amendments (biochar). Grazing management (primarily rest) will be necessary to ensure any new seedling establishment.

## **Restoration pathway R5D**

### **State 5 to 4**

If utilizing the phases established by Miller et al management and restoration methods will vary. An large majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's Phases. This Restoration Pathway is exceedingly rare as it is typically not cost effect for land managers to manage for a degraded state. Phase I may exhibit None-Slight to Moderate departures from rangeland health where removal of the conifers via Brush Management and/or Prescribed fire combined. If mechanical removal of conifers is utilized, no grazing management is needed assuming relatively conservative management had been used prior to treatment. If prescribed fire is utilized, short term grazing deferment and/or rest is suggested. Given a short time removal of a Phase I encroachment will recover to Reference. Proactive pest management is encouraged. Phase II Encroachment may require a more intense mechanical removal of trees/shrubs with Prescribed Fire not being a feasible method of control as this community may be at risk of catastrophic fire due to canopy density. Phase II displays a Moderate departure from Reference suggesting an overall instability of the site such as reduced herbaceous production, reduced functional/structural groups (e.g. reduced mid-statured bunchgrasses), increase rill frequency and length, and possibly increased bare ground. Increased post treatment grazing management may be necessary. Grazing management may be as simple as short term growing season deferment however long term rest may be necessary in the latter stages of Phase II encroachment. Latter stages of Phase II encroachment will likely require some short term erosion mitigation such as straw waddles as well as range planting and/or critical area planting to re-establish any loss of native herbaceous plants particularly mid-statured cool season bunchgrasses. Phase III Encroachment canopy cover resembles forested sites with larger trees and shrubs. Forest management style tree removal (woody debris and logs removed from the site) will be necessary prior to any prescribed burning as to prevent the fire from burning too hot. The result of a prescribed fire on this site are typically

unknown as seed sources of native herbaceous plants are usually limited to small patches. Since herbaceous plants will likely have been depleted under a Phase III encroachment, there is an opportunity for large areas of bare ground, increase rill and in some cases gully erosion. Post treatment will require range planting and/or critical area seeding, erosion control, pest management, and possibly soil carbon amendments (biochar). Grazing management (primarily rest) will be necessary to ensure any new seedling establishment.

## Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Mid-Statured bunchgrasses</b>			925–1289	
	bluebunch wheatgrass	PSSP6	<i>Pseudoroegneria spicata</i>	701–1093	35–55
	rough fescue	FECA4	<i>Festuca campestris</i>	168–308	15–20
	green needlegrass	NAVI4	<i>Nassella viridula</i>	112–252	15–20
	needle and thread	HECO26	<i>Hesperostipa comata</i>	84–168	10–15
	basin wildrye	LECI4	<i>Leymus cinereus</i>	0–56	0–3
2	<b>Shortgrasses/sedges</b>			168–269	
	Idaho fescue	FEID	<i>Festuca idahoensis</i>	67–112	3–10
	prairie Junegrass	KOMA	<i>Koeleria macrantha</i>	45–90	3–6
	Sandberg bluegrass	POSE	<i>Poa secunda</i>	45–90	3–6
	needleleaf sedge	CADU6	<i>Carex duriuscula</i>	22–67	1–3
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	22–45	1–3
	threadleaf sedge	CAFI	<i>Carex filifolia</i>	0–39	0–2
3	<b>Rhizomatous grasses</b>			101–213	
	western wheatgrass	PASM	<i>Pascopyrum smithii</i>	67–168	2–6
	thickspike wheatgrass	ELLA3	<i>Elymus lanceolatus</i>	67–168	2–6
	plains reedgrass	CAMO	<i>Calamagrostis montanensis</i>	0–45	0–2
<b>Forb</b>					
4	<b>Forbs</b>			84–135	
	purple prairie clover	DAPU5	<i>Dalea purpurea</i>	45–112	3–5
	American vetch	VIAM	<i>Vicia americana</i>	45–112	1–4
	dotted blazing star	LIPU	<i>Liatris punctata</i>	45–112	1–3
	common yarrow	ACMI2	<i>Achillea millefolium</i>	22–90	0–2
	scarlet globemallow	SPCO	<i>Sphaeralcea coccinea</i>	22–84	1–2
	cinquefoil	POTEN	<i>Potentilla</i>	0–67	0–3
	spiny phlox	PHHO	<i>Phlox hoodii</i>	0–67	0–3
	silvery lupine	LUAR3	<i>Lupinus argenteus</i>	22–56	1–2
	slimflower scurfpea	PSTE5	<i>Psoraleidum tenuiflorum</i>	22–45	0–2
	desertparsley	LOMAT	<i>Lomatium</i>	11–45	1–2
	bastard toadflax	COUM	<i>Comandra umbellata</i>	0–45	0–1
	Missouri goldenrod	SOMI2	<i>Solidago missouriensis</i>	0–45	0–1
	hairy false goldenaster	HEVI4	<i>Heterotheca villosa</i>	22–45	0–1
	little larkspur	DEBI	<i>Delphinium bicolor</i>	0–22	0–1
	fleabane	ERIGE2	<i>Erigeron</i>	11–22	0–1

	buckwheat	ERIOG	<i>Eriogonum</i>	11–22	0–1
	onion	ALLIU	<i>Allium</i>	0–22	0–1
	Drummond's milkvetch	ASDR3	<i>Astragalus drummondii</i>	0–22	0–1
	milkvetch	ASTRA	<i>Astragalus</i>	0–22	0–1
<b>Shrub/Vine</b>					
5	<b>Shrubs</b>			101–196	
	Wyoming big sagebrush	ARTRW8	<i>Artemisia tridentata ssp. wyomingensis</i>	67–196	10–15
	common snowberry	SYAL	<i>Symphoricarpos albus</i>	11–67	1–5
	spineless horsebrush	TECA2	<i>Tetradymia canescens</i>	0–67	0–3
	yellow rabbitbrush	CHVI8	<i>Chrysothamnus viscidiflorus</i>	11–45	1–3
	Woods' rose	ROWO	<i>Rosa woodsii</i>	11–45	1–3
	rubber rabbitbrush	ERNA10	<i>Ericameria nauseosa</i>	0–45	0–2
6	<b>Subshrubs</b>			22–56	
	winterfat	KRLA2	<i>Krascheninnikovia lanata</i>	22–56	1–3
	slender buckwheat	ERMI4	<i>Eriogonum microthecum</i>	0–22	0–1
	white sagebrush	ARLU	<i>Artemisia ludoviciana</i>	0–22	0–1
	prairie sagewort	ARFR4	<i>Artemisia frigida</i>	0–22	0–1
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	0–11	0–1

## Animal community

The Loamy Steep ecological site provides 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 have been replaced, mostly with domesticated livestock, elk and antelope still frequently 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 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 Mid-Staturred Bunchgrass Community (1.1) is likely to have this minimum sagebrush cover for sage grouse presence given its low to moderate sagebrush canopy cover. Also, the potentially diverse forage component of the Reference State may provide important early-season (spring) foraging habitat for the greater sage grouse. Other communities on the site with sufficient sagebrush cover may harbor sage grouse populations, specifically Community 2.1, where big sagebrush populations increased under a reduced fire regime. Also, as sagebrush canopy cover increases under Altered States 2.1 and 2.2 and, to a limited extent, in Degraded State 3.1, pygmy rabbit, Brewer's sparrow, pronghorn antelope, 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. This is often a preferred site for grazing by livestock, and animals tend to congregate in these areas. To maintain the productivity of the Loamy site, grazing on adjacent sites with lower productivity must be carefully managed to ensure that utilization on this site is not excessive. Management objectives should include maintenance or improvement of the native plant community. Careful management of the 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. 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 bluebunch.

Since needle and thread normally matures earlier than bluebunch wheatgrass and rough fescue and produces a sharp awn, this species is usually avoided after seed set. Changing the grazing season of use will help utilize needle and thread more efficiently while preventing overuse of bluebunch wheatgrass and rough fescue.



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

Continual non-prescribed grazing of this site will be detrimental, will alter the plant composition and production over time, and will result in the transition to the Altered 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 Altered State is subject to further degradation to the Degraded State or 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 an increased risk of 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 the species composition of invasive species. Grazing may be possible in a Degraded State, but it is generally not economically or environmentally sustainable.

## **Hydrological functions**

The hydrologic cycle functions best in the Reference 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. High ground cover reduces raindrop impact on the soil surface, which keeps erosion and sedimentation transport low. Water leaving the site will have a 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 Mid-Staturred Bunchgrass 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 nonexistent. 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 the bare ground will be less than 15 percent. Therefore, the hydrologic cycle is functioning at a level similar to the water cycle in the Mid-Staturred Bunchgrass Community (1.1). Compared to the Mid-Staturred Bunchgrass Community (1.1), infiltration rates are slightly reduced and surface runoff is slightly higher.

In the Shortgrass Community (2.2), the Degraded 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, the 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 the frequency and severity of flooding within a watershed. Soil erosion is accelerated, the quality of surface runoff is poor, and sedimentation increases.

The hydrology of the Conifer Encroached State (5) is highly variable, but studies suggest that an increased tree canopy affects the interception of rainfall and reduces available soil moisture for herbaceous vegetation. This can negatively affect infiltration and increase runoff.

## **Recreational uses**

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

## **Wood products**

none

## Other products

none

## Inventory data references

Information presented was derived from the site's Range Site Description (Loamy Steep 15-19" P.Z., Northern Rocky Mountain Valleys, South, East of Continental Divide), NRCS clipping 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).

## References

. Fire Effects Information System. <http://www.fs.fed.us/database/feis/>.

. 2021 (Date accessed). USDA PLANTS Database. <http://plants.usda.gov>.

Arno, S.F. and G.E. Gruell. 1982. Fire History at the Forest-Grassland Ecotone in Southwestern Montana. *Journal of Range Management* 36:332–336.

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

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.

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

Blaisdell, J.P. and R.C. Holmgren. 1984. Managing Intermountain Rangelands--Salt-Desert Shrub Ranges. General Tech Report INT-163. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT. 52.

Bunting, S.C., B.M. Kilgore, and C.L. Bushey. 1987. Guidelines for Prescribe burning sagebrush-grass rangelands in the Northern Great Basin. General Technical Report INT-231. USDA Forest Service Intermountain Research Station, Ogden, UT. 33.

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

Daubenmire, R. 1970. *Steppe vegetation of Washington*.

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.
- Hobbs, J.R. and S.E. Humphries. 1995. An integrated approach to the ecology and management of plant invasions. *Conservation Biology* 9:761–770.
- Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States.
- Lacey, J.R., C.B. Marlow, and J.R. Lane. 1989. Influence of Spotted knapweed (*Centaurea maculosa*) on surface runoff and sediment yield.. *Weed Technology* 3:627–630.
- Lesica, P. and S.V. Cooper. 1997. Presettlement vegetation of Southern Beaverhead County, MT.
- Manske, L.L. 1980. Habitat, phenology, and growth of selected sandhills range plants.
- Masters, R. and R. Sheley. 2001. Principles and practices for managing rangeland invasive plants. *Journal of Range Management* 38:21–26.
- McCalla, G.R., W.H. Blackburn, and L.B. Merrill. 1984. Effects of Livestock Grazing on Infiltration Rates of the Edwards Plateau of Texas. *Journal of Range Management* 37:265–269.
- 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.
- 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.
- Moulton, G.E. and T.W. Dunlay. 1988. *The Journals of the Lewis and Clark Expedition*. Pages in University of Nebraska Press.
- Mueggler, W.F. and W.L. Stewart. 1980. Grassland and Shrubland Habitat Types of Western Montana.
- Pelant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. Interpreting Indicators of Rangeland Health.
- Pellant, M. and L. Reichert. 1984. Management and Rehabilitation of a burned winterfat community in Southwestern Idaho. Proceedings--Symposium on the biology of Atriplex and related Chenopods. 1983 May 2-6; Provo UT General Technical Report INT-172.. USDA Forest Service Intermountain Forest and Range Experiment Station. 281–285.
- Pitt, M.D. and B.M. Wikeem. 1990. Phenological patterns and adaptations in an *Artemisia/Agropyron* plant community. *Journal of Range Management* 43:350–357.
- Pokorny, M.L., R. Sheley, C.A. Zabinski, R. Engel, T.J. Svejcar, and J.J. Borkowski. 2005. Plant Functional Group Diversity as a Mechanism for Invasion Resistance.

Wambolt, C. and G. Payne. 1986. An 18-Year Comparison of Control Methods for Wyoming Big Sagebrush in Southwestern Montana. *Journal of Range Management* 39:314–319.

West, N.E. 1994. Effects of Fire on Salt-Desert shrub rangelands. Proceedings--Ecology and Management of Annual Rangelands: 1992 May 18-22. Boise ID General Technical Report INT-GTR-313.. USDA Forest Service Intermountain Research Station. 71–74.

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.

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.

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## Approval

Kirt Walstad, 9/11/2023

## 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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Contact for lead author	grant.petersen@usda.gov
Date	03/01/2020
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

## Indicators

1. **Number and extent of rills:** Rills are not present in the reference condition on slopes less than 20%, if present will be short and inconspicuous on the steepest southerly facing slopes.

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2. **Presence of water flow patterns:** Water flow patterns are rare in the reference condition but may be present on the steeper, south facing slopes (>25%) when runoff exceeds infiltration. These patterns will be short and infrequent across the landscape.

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3. **Number and height of erosional pedestals or terracettes:** Pedestals are rarely evident in the reference condition, if

present will be on slopes greater than 25% and associated with waterflow patterns.

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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 low (10-15 percent). It consists of randomly scattered patches.

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5. **Number of gullies and erosion associated with gullies:** Gullies are not present in the reference condition.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Wind scoured, or depositional areas are not evident to extremely rare in the reference condition.

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7. **Amount of litter movement (describe size and distance expected to travel):** Litter movement is minimal in the reference condition. Litter movement is less than 1 ft.

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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):** The average soil stability rating is 4-6 under plant canopies and 3-6 in plant interspaces. The A horizon is 4-6 inches thick.

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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 typically weak fine to medium fine granular. A Horizon should be 4-6 inches thick with color, when wet, Value of 3 or less and Chroma of 3 or less. Local geology may affect color in which 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:**

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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):** Evenly distributed across the site, bunchgrasses improve infiltration while rhizomatous grass protects the surface from runoff forces. Infiltration of the Loamy ecological site is well drained but has a slow infiltration rate. An even distribution of mid stature grasses, ~60-70% of site production, cool season rhizomatous grasses 10-15% of site production along with a mix of shortgrass, forbs and shrubs (10-20%).

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**  
  
Dominant:  
  
Sub-dominant:  
  
Other:  
  
Additional:

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

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

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

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

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17. **Perennial plant reproductive capability:**

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