Ecological site EX044B01A031
Limy Droughty (LyDr) LRU 01 Subset A

Last updated: 9/08/2023
Accessed: 04/18/2024

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

MLRA notes

Major Land Resource Area (MLRA): 044B–Central Rocky Mountain Valleys

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

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

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

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

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

LRU notes

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

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

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

Classification relationships

Mueggler and Stewart. 1980. Grassland and Shrubland habitat types of Western Montana
1. Stipa comata/*Bouteloua gracilis* h.t.
2. Agropyron spicatum/*Bouteloua gracilis* h.t.

Montana Natural Heritage Program Vegetation Classification
1. Stipa comata - *Bouteloua gracilis* Herbaceous Vegetation
(STICOM – BOUGRA) Needle and thread/Blue grama
Natural Heritage Conservation Rank-G5 / S5
Edition / Author- 99-11-16 / S.V. Cooper,

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

The Limy Droughty ecological site is an upland site formed from colluvium, alluvium, or slope alluvium and is on slopes less than 60 percent. The site does not receive additional moisture from a water table or flooding. It is moderately deep to very deep and has no root-restrictive layers within 20 inches (50cm). The surface of the site has less than five percent stone and is skeletal, with 35 percent or more rock fragments in the 10 to 20-inch depth. Soil surface texture ranges from sandy loam to clay loam in surface mineral 4 inches. The site does not have a saline or saline-sodic influence and is strongly or violently effervescent within four inches of the mineral surface. Calcium carbonates may increase with depth.

Associated sites

EX044B01A030	**Limy (Ly) LRU 01 Subset A** Limy ecological site occupies the same general landscape as the Limy Droughty.
EX044B01A036	**Droughty (Dr) LRU 01 Subset A** Shallow to Gravel, Limy tends to occupy the landscape position above the Limy Droughty site.

Similar sites

EX044B01A036	**Droughty (Dr) LRU 01 Subset A** The Droughty ecological site has a similar core plant community but differs in that it is not strongly or violently effervescent in the surface 4” of soil.

EX044B01A137	**Shallow to Gravel Limy (SwGrLy) LRU 01 Subset A** The Shallow to Gravel, Limy ecological site shares a similar reference plant community however site differs in that the soil is sandy skeletal within 10-20” of soil surface and produces less above ground biomass
EX044B01A030	**Limy (Ly) LRU 01 Subset A** The Limy ecological site differs by being not skeletal within 20”. Plant community is nearly identical with the exception of producing lower amounts of bluebunch wheatgrass.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Chrysothamnus viscidiflorus* (2) *Artemisia tridentata ssp. wyomingensis*
Herbaceous	(1) *Pseudoroegneria spicata* (2) *Hesperostipa comata*

Legacy ID

R044BA031MT

Physiographic features

This ecological site occurs on slopes ranging from nearly level to 60 percent; however, the representative slope is 4 to 10 percent. It is an area of dissected mountain valleys. The parent material is tertiary valley fill, alluvium, and slope alluvium of mixed geology.

Table 2. Representative physiographic features

Landforms	(1) Intermontane basin > Terrace (2) Intermontane basin > Fan remnant (3) Intermontane basin > Alluvial fan
Ponding frequency	None
Elevation	4,500–6,000 ft
Slope	4–10%
Water table depth	100 in
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Ponding frequency	Not specified
Elevation	Not specified
Slope	1–60%
Water table depth	Not specified

Climatic features

The Central Rocky Mountain Valleys MLRA has a continental climate. Fifty to sixty percent of the annual long-term average precipitation falls between May and August. Average precipitation for LRU A is 12 inches (305mm), and the frost-free period averages 78 days.
Precipitation is highest in May and June.

Table 4. Representative climatic features

Frost-free period (characteristic range)	70-110 days

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

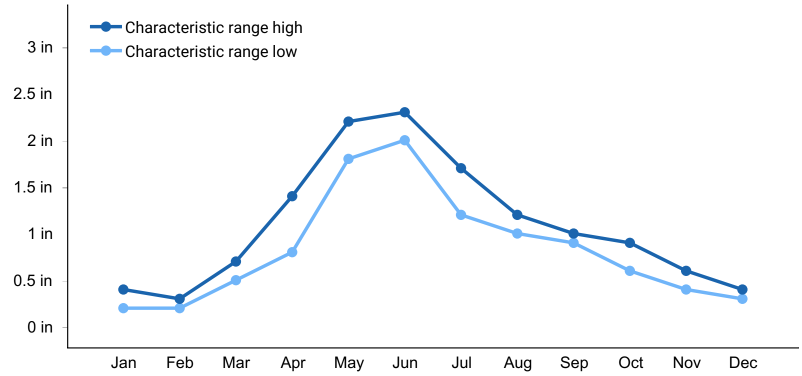


Figure 1. Monthly precipitation range

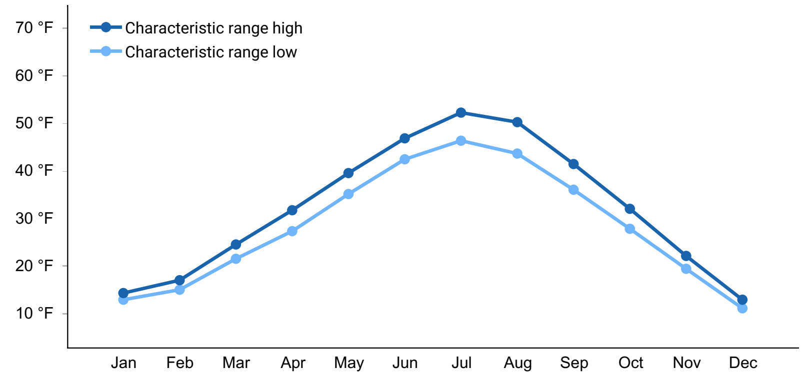


Figure 2. Monthly minimum temperature range

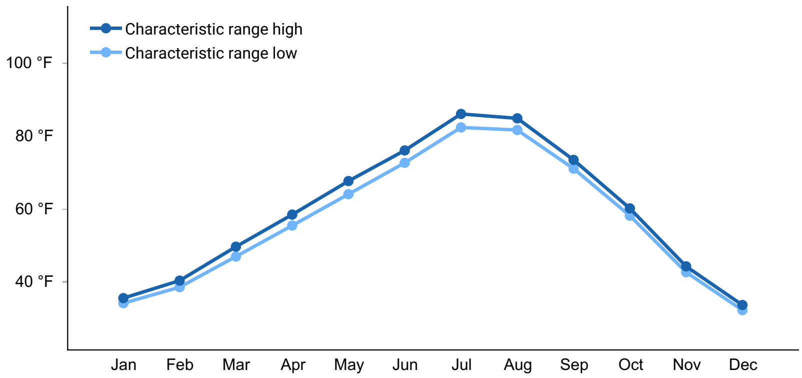


Figure 3. Monthly maximum temperature range

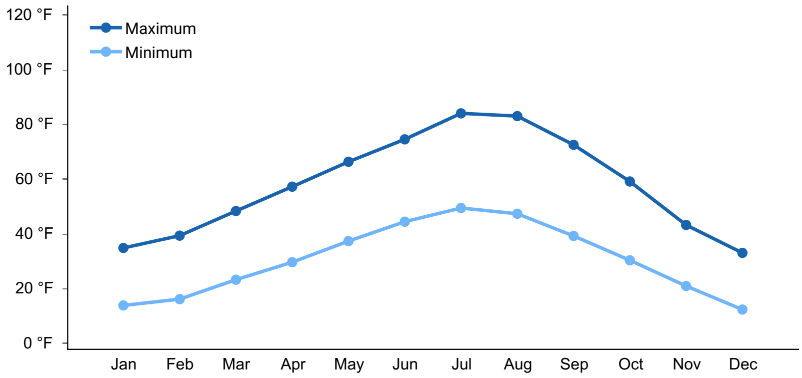


Figure 4. Monthly average minimum and maximum temperature

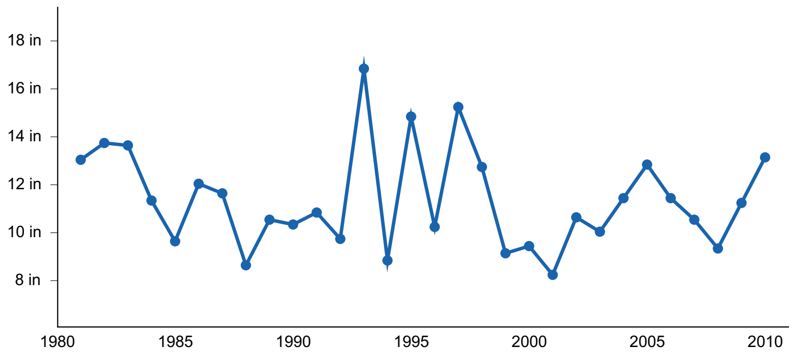


Figure 5. Annual precipitation pattern

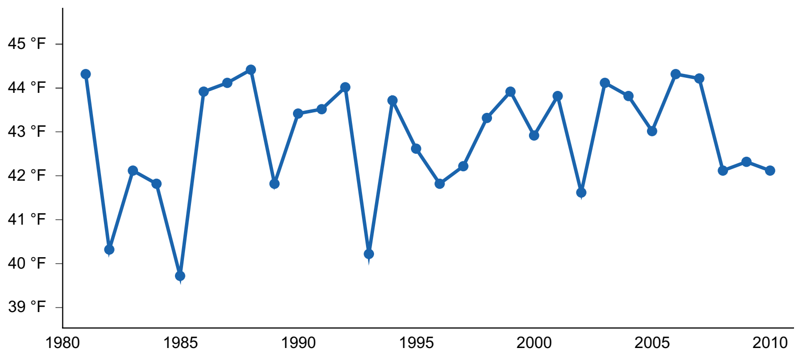


Figure 6. Annual average temperature pattern

Climate stations used

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

Influencing water features

There are no water features influencing this site.

Wetland description

This site is not associated with wetlands.

Soil features

These soils are moderately deep to very deep, moderately to moderately rapid permeability, and well drained. These soils are formed from alluvium, colluvium, and slope alluvium. The soil is loamy-skeletal (rock fragments account for more than 35 percent of the volume in the 10 to 20-inch layer). This skeletal material decreases the water-holding capacity of the site. Typically, soil surface textures consist of loam, sandy loam, and loamy sand textures. Soils are also typically gravelly, very gravelly, very stony, or cobbly. Common soil series are Crago and Bronec. These soils may exist across multiple ecological sites due to natural variations in slope, texture, rock fragments, and pH. An onsite soil pit and the most current ecological site key are required to classify an ecological site.

Table 5. Representative soil features

Parent material	(1) Alluvium–igneous, metamorphic and sedimentary rock (2) Slope alluvium–igneous, metamorphic and sedimentary rock
Surface texture	(1) Gravelly loam (2) Sandy loam (3) Loamy sand
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Moderately slow to moderately rapid
Soil depth	20 in
Surface fragment cover <=3"	0–20%
Surface fragment cover >3"	0–10%
Available water capacity (0-40in)	1.9–5.8 in
Calcium carbonate equivalent (0-40in)	20%
Electrical conductivity (0-40in)	0–1 mmhos/cm
Sodium adsorption ratio (0-40in)	0–13
Soil reaction (1:1 water) (0-40in)	7.9–8.4
Subsurface fragment volume <=3" (10-20in)	35–60%
Subsurface fragment volume >3" (10-20in)	20–55%

Ecological dynamics

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

The Limy Droughty ecological site occurs across a relatively large landscape; slight variations within the plant community occur due to elevation, frost-free days, and relative effective annual precipitation. Bluebunch wheatgrass, for example, occupies all known combinations of elevation and climate; however, under a drier moisture regime, it often shares dominance with needle and thread. These warmer, drier sites also tend to exhibit higher populations of warm-season shortgrasses such as blue grama and sand dropseed, especially when soil surface textures trend toward sandy loams. Conversely, colder, wetter sites within this Land Resource Unit often exhibit slight increases in Wyoming big sagebrush production, while bluebunch wheatgrass production also increases. Cold, dry rainshadow locations near the bases of the mountains express black sagebrush (*Artemisia nova*) as a dominant shrub.

Historical records indicate that, prior to the introduction of livestock (cattle and sheep) during the late 1800s, elk and bison grazed this ecological site. Because of the nomadic nature and herd structure of bison, grazed areas received periodic, high-intensity, short-duration grazing pressure. Livestock forage was noted as being minimal in areas recently grazed by bison (Lesica and Cooper 1997). Meriwether Lewis documented that he was met by 60 Shoshone warriors on horseback in August 1805, and the Corps of Discovery was later supplied with horses by the same band of Shoshone. This suggests that the areas near the modern-day Montana towns of Twin Bridges, Dillon, Grant, and Dell were grazed by an untold number of horses for nearly 50 years prior to the large introduction of cattle and sheep. The gold boom of the 1860s brought the first herds of livestock overland from Texas, and homesteaders began settling the area. During this time, cattle were the primary domestic grazers in the area. In the 1890s, sheep production increased by more than 400 percent and dominated the livestock industry until the 1930s. Since then, cattle production has dominated the region's livestock industry (Wyckoff and Hansen 2001).

Natural fire was a frequent ecological driver of this ecological site; however, due to the relatively low plant density and fire-resistant nature of the plants (saltbush and greasewood), stand replacement was rare. The reference community with a high amount of herbaceous growth as a result of favorable growing conditions has the highest susceptibility to extreme fire. A herbaceous invaded community that contains high amounts of exotic annual grasses can greatly increase the risk of fire frequency and intensity, resulting in the potential removal of native species.

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*), cheatgrass (Bromus techtorum), Canada thistle (*Cirsium arvense*), dandelion (Taraxicum spp.), and Kentucky bluegrass (*Poa pratensis*). Invasive weeds have a high impact on this ecological site, and cheatgrass poses the highest risk of invasion.

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

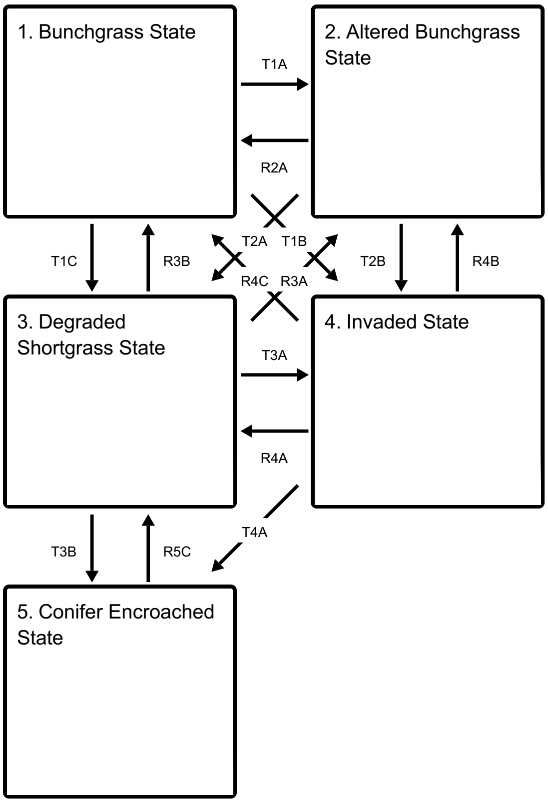
The plant communities within the same ecological site will differ across the MLRA due to the naturally occurring variability in weather, soils, and aspect. The biological processes on this site are complex; therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are intended to cover the core species and the known range of conditions and responses.

Both percent species composition by weight and percent canopy cover are referenced in this document. Canopy cover drives the transitions between communities and states because of the influence of shade, the interception of rainfall, and the competition for available water. Species composition by dry weight remains an important descriptor of the herbaceous community and of the community as a whole. Woody species are included in the species composition for the site. Calculating the similarity index requires species composition by dry weight.

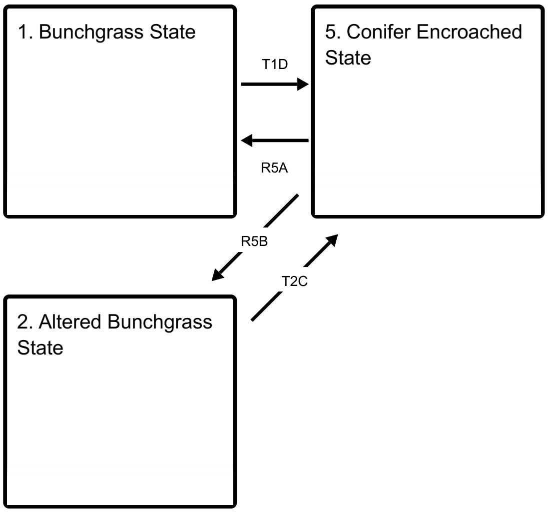
Although there is considerable qualitative experience supporting the pathways and transitions within the State and Transition Model (STM), no quantitative information exists that specifically identifies threshold parameters between grassland types and invaded types in this ecological site. For information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

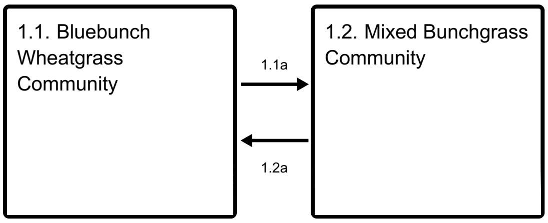
Ecosystem states



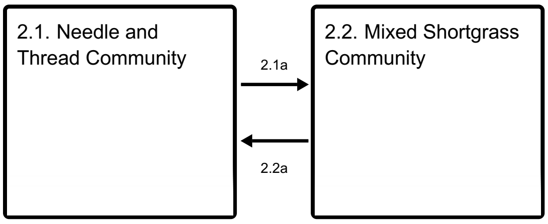
States 1, 5 and 2 (additional transitions)



State 1 submodel, plant communities

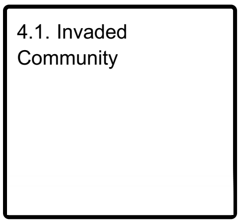


State 2 submodel, plant communities



State 3 submodel, plant communities

State 4 submodel, plant communities



State 5 submodel, plant communities

5.1. Conifer Encroached Community

State 1
Bunchgrass State

The Reference State of this ecological site consists of two known potential plant communities, the Bluebunch Community and the Mixed Bluebunch Community. These are described below but are generally characterized by a mid-statured, cool-season grass community with limited shrub production. Community 1.1 is dominated by bluebunch wheatgrass and is considered the reference, while Community 1.2 has a codominance of bluebunch and needle and thread with an increase in green rabbitbrush and Wyoming big sagebrush. These communities may meld into each other due to the varying conditions that occur in Southwest Montana, particularly during dry cycles where the needle and thread growth cycle takes better advantage of the limited moisture.

Community 1.1
Bluebunch Wheatgrass Community

Figure 7. Bluebunch wheatgrass community phase

In the Reference Plant Community bluebunch wheatgrass (*Pseudoroegneria spicata*) and needle and thread (*Hesperostipa comata*) are typically dominant, and Indian ricegrass (*Achnatherum hymenoides*) and winterfat (*Krascheninnikovia lanata*) are subordinates. Shrub species (Wyoming big sagebrush, fringed sagewort, and broom snakeweed) remain a minor part of the community. Gardner’s saltbush and black sagebrush (*Artemisia nova*) also occur at lower production values. Sandberg bluegrass (*Poa secunda*) and dryland sedges are also common. This state occurs on the Limy Droughty 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). The Bluebunch Wheatgrass 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. Infrequent fire probably maintained Wyoming big sagebrush communities as open, seral stands of Wyoming big sagebrush with productive herbaceous understories. Wyoming big sagebrush steppe communities historically had low fuel loadings and were characterized by 10- to 70-year interval fires that produced a mosaic of burned and unburned lands (Bunting et al., 1987). Following the 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 the nearly complete destruction of scattered sagebrush (Arno and Gruell 1983). Gardner's saltbush is described as fire resistant because it contains high concentrations of minerals that increase char formation but low concentrations of volatile, flammable compounds (West 1994). Winterfat is tolerant of low-intensity fire but will kill with a hot fire (Pellant 1984). Blue grama and sand dropseed, both warm-season species, are most often seen in

Limy Droughty sites that have a sandy loam surface.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	510	722	807
Shrub/Vine	48	68	76
Forb	42	60	67
Tree	0	0	0
Total	**600**	**850**	**950**

Table 7. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0-5%
Litter	30-40%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	10-25%

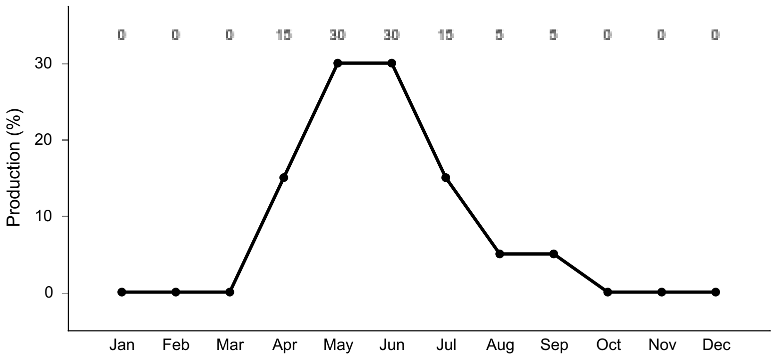


Figure 9. Plant community growth curve (percent production by month). MT44B032, Dry Uplands. Cool season grass dominated system. Most dry, upland sites located within MLRA 44B LRU A are characterized by early season growth which is mostly complete by Mid-July. Limited fall "green-up" if conditions allow..

Community 1.2
Mixed Bunchgrass Community

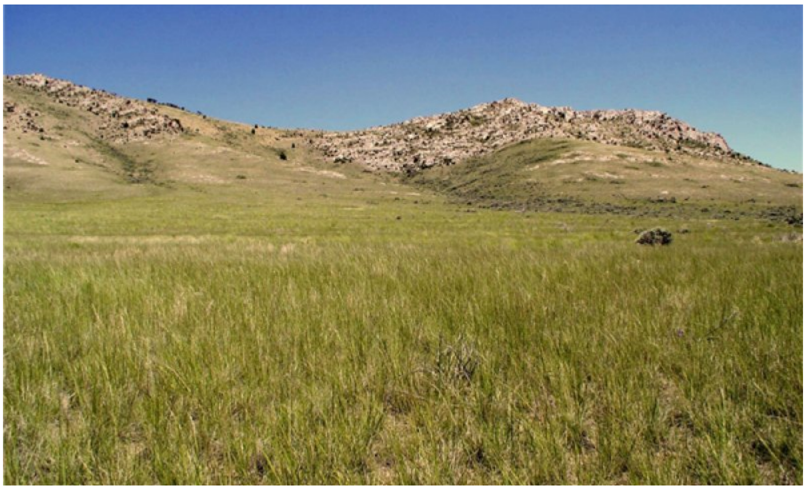


Figure 10. Mixed Bunchgrass Community. Notice the increased needle and thread.

With proper grazing management over time, this site can come close to the diversity and complexity of the Bluebunch Wheatgrass Community (1.1). Without active management, the site is not likely to return to near Reference Plant Community. Needle-and-thread tolerates grazing pressure better than bluebunch wheatgrass. Bluebunch wheatgrass grass has a growing point several inches above the ground, making it vulnerable to continued close grazing (Smoleack et al., 2006). It increases in species composition when more palatable and less grazing-tolerant plants decrease due to improper grazing management. Needle and thread and bluebunch wheatgrass share dominance in the Mixed Bunchgrass Community (1.2). Other grass species that are more tolerant to grazing and are likely to increase in number compared to the Reference Plant Community include Sandberg bluegrass (*Poa secunda*), prairie Junegrass, western/thickspike wheatgrass (*Pascopyrum smithii*, *Elymus lanceolatus*), and blue grama (*Bouteloua gracilis*). Some increaser forbs species include western yarrow, spiny phlox (*Phlox hoodii*), scarlet globemallow (*Sphaeralcea coccinea*), hairy goldenaster, and pussytoes (Antennaria spp.). Fringed sagewort (*Artemisia frigida*) is a shrub that also increases under prolonged drought or heavy grazing and can respond to precipitation that falls in July and August. Heavy, continuous grazing will reduce plant cover, litter, and mulch. The timing of grazing is important on this site because of the moisture limitations beyond June, especially on the drier sites. Bare ground will increase, exposing the soil to erosion. Litter and mulch will be reduced as plant cover declines. Under proper grazing management and favorable growing conditions, the site can be returned to the Bluebunch Wheatgrass Community (Pathway 1.2A) as long as the production of bluebunch wheatgrass is greater than 15 percent of total biomass production. Needle and thread will continue to increase until it makes up 50 percent or more of species composition. Once Bluebunch wheatgrass has been reduced to less than 10 percent composition, it may be difficult for the site to recover to Reference Plant Community (1.1). The risk of soil erosion increases when canopy cover decreases below 50 percent. As soil conditions degrade, there will be a loss of organic matter, reduced litter, and reduced soil fertility. Degraded soil conditions increase the difficulty of reestablishing bluebunch wheatgrass and returning to the Reference Community (1.1). The Mixed Bunchgrass Community (1.2) is the at-risk plant community for this ecological site. When overgrazing continues, increaser species such as needle-and-thread and native forb species will become more dominant, and this triggers the change to the Altered Bunchgrass State (2) or the Degraded Shortgrass State (3). Until the Mixed Bunchgrass Community (1.2) crosses the threshold into the Needle and Thread Community (2.1) or the Invaded Community (4.1), this community can be managed toward the Bluebunch Wheatgrass Community (1.1) using prescribed grazing and strategic weed control. It may take several years to achieve this recovery, depending on growing conditions, the vigor of remnant bluebunch wheatgrass plants, and the aggressiveness of the weed treatments.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	477	595	765
Shrub/Vine	56	70	90
Forb	28	35	45
Total	**561**	**700**	**900**

Pathway 1.1a
Community 1.1 to 1.2

Bluebunch Wheatgrass Community

Mixed Bunchgrass Community

Bluebunch wheatgrass loses vigor with improper grazing or extended drought. When vigor declines enough for plants to die or become smaller, species with higher grazing tolerance (in this ecological site, needle and thread) increase in vigor and production as they access the resources previously used by bluebunch wheatgrass. The decrease in species composition by weight of bluebunch wheatgrass to less than 50 percent indicates that the plant community has shifted to the Mixed Bunchgrass Community (1.2). The driver for community shift 1.1A is improper grazing management or prolonged drought. This shift is triggered by the loss of vigor of bluebunch wheatgrass, soil erosion, or prolonged drought coupled with improper grazing. Blaisdell (1958) stated that drought and warmer-than-normal temperatures are known to advance plant phenology by as much as one month. During drought years, plants may be especially sensitive or reach a critical stage of development earlier than expected. 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

Mixed Bunchgrass Community

Bluebunch Wheatgrass Community

The Mixed Bunchgrass Community (1.2) will return to the Bluebunch Wheatgrass Community (1.1) with proper grazing management and appropriate grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. It may take several years of favorable conditions for the community to transition back to a bluebunch dominated state. The driver for this community shift (1.2A) is the increased vigor of bluebunch wheatgrass, to the point that it represents more than 50 percent of species composition. The trigger for this shift is the change in grazing management favoring bluebunch wheatgrass.

Conservation practices

Prescribed Grazing

State 2
Altered Bunchgrass State

This state is characterized by having less than 10 percent bluebunch wheatgrass by dry weight. It is represented by two communities that differ in the percent composition of needle and thread, production, and soil degradation. Production in this state can be similar to that in the Bunchgrass State (1). Some native plants tend to increase under prolonged drought and/or heavy grazing practices. A few of these species may include needle and thread, Sandberg bluegrass, scarlet globemallow, hairy goldenaster, and fringed sagewort. The Lewis and Clark journals (Moulton 1988) talk about the areas around the Hogback, north of Dillon, and Horse Prairie, west of Clark Canyon Reservoir: "The soil of the plains is a light yellow clay, very meager and intermixed with a large proportion of gravel, producing nothing except the twisted or bearded grass, sedge, and prickly pears". Many of their journeys were hampered by needle and thread awns in their moccasins. This may suggest that there was extensive, repeated use prior to the Corps of Discovery expedition. Today, needle and thread dominates that area, suggesting that transitioning from the Altered Bunchgrass State back to the Reference State may require multiple years of recovery, reaffirming the Domaar 1997 study.

Community 2.1
Needle and Thread Community

Figure 12. Needle-and-thread Altered state

Long-term grazing mismanagement with continuous growing-season pressure will reduce the total productivity of the site and lead to an increase in bare ground. Once plant cover is reduced, the site is more susceptible to erosion and degradation of soil properties. Soil erosion or reduced soil fertility will result in reduced plant production. This soil erosion or loss of soil fertility indicates the transition to the Altered Bunchgrass State (2) because it creates a threshold requiring energy input to return to the Bunchgrass State (1). Transition to the Needle and Thread Community (2.1) may be exacerbated by extended drought conditions. Bluebunch wheatgrass makes up less than 10 percent of the species composition by dry weight, and the remaining bluebunch wheatgrass plants tend to be scattered and low in vigor. Increaser and invader species may becom more common and create more competition for bluebunch wheatgrass. This makes it difficult for bluebunch wheatgrass to quickly respond to a change in grazing management alone. As a result, an energy input is required for the community to return to Bunchgrass State. 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 Bunchgrass State. 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 Bunchgrass State. This state has lost soil or vegetation attributes to the point that recovery to the Bunchgrass State will require reclamation efforts, i.e., soil rebuilding, intensive mechanical treatments, and/or reseeding. The transition to this state could result from overgrazing, especially repeated early-season grazing, or extensive drought. If heavy grazing continues, plant cover, litter, and mulch will continue to decrease, and bare ground will increase, exposing the soil to accelerated erosion. Litter and mulch will move off-site as plant cover declines. The Needle and Thread Community will then shift to the Mixed Shortgrass Community (2.2). Continued improper grazing will drive the community to a Degraded Shortgrass State (3). Introduction or expansion of invasive species will further drive the plant community into the Invaded State (4).

Community 2.2
Mixed 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) will increase in vigor and production as they respond to resources previously used by the bunchgrasses. These less desirable, shallow-rooted species will become co-dominant with the taller bunchgrasses. Shrubs will become more competitive for limited moisture as bare ground and soil erosion increase.

Pathway 2.1a
Community 2.1 to 2.2

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

Pathway 2.2a
Community 2.2 to 2.1

If proper grazing management is implemented, needle and thread may regain its vigor and move towards the Needle and Thread 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 Plant 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). Shrub removal and favorable growing conditions can accelerate this process. If the site contains Wyoming big sagebrush, low-intensity fire or mechanical treatment (Wambolt 1986) could reduce shrub competition and allow for increased vigor and the reestablishment of grass species.

State 3
Degraded Shortgrass State

Degraded State lacks mid-statured bunchgrasses. The dominant grasses are Sandberg bluegrass, western wheatgrass, and prairie Junegrass, while increaser shrubs have nearly replaced 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).

Community 3.1
Shortgrass/Rhizomatous Community

Soil loss continues as a result of reduced plant basal areas. Native perennial grasses make up less than 350 pounds of annual dry weight production. Grass and forb cover may be very sparse or clumped. Weeds, annual species, or shrubs dominate the plant community. Mid-stature perennial bunchgrass species such as needle and thread will have significantly reduced growth habits, and bluebunch wheatgrass will only exist in large shrub canopies. This is a result of failure to adjust stocking rates to declining forage production due to increased invasive dominance. In the most severe stages of degradation, there is a significant amount of bare ground, and large gaps occur between plants. Potential exists for soils to erode to the point that irreversible damage may occur. This is a critical shift in the ecology of the site. Soil erosion combined with a lack of organic matter deposition due to sparse vegetation creates changes to the hydrology, soil chemistry, soil microorganisms, and soil structure to the point where intensive restoration is required to restore the site to another state or community. Changing management (i.e., improving grazing management) cannot create sufficient change to restore the site within a reasonable time frame. This state is characterized by soil surface degradation and little plant soil surface cover. Shrub canopy cover is usually greater than 15 percent. Big sagebrush is replaced with a dominant community of broom snakeweed, green rabbitbrush, fringed sagewort, and plains prickly pear cactus. This state has lost soil or vegetation attributes to the point that recovery for the Bunchgrass State will require reclamation efforts, i.e., soil rebuilding, intensive mechanical treatments, and/or reseeding. This plant community may be in a terminal state and will not return to the reference state because of degraded soil conditions and the loss of higher successional native plant species. Key factors in the approach to transition include: a decrease in grass canopy cover and production; an increase in shrub canopy cover; increases in mean bare patch size, increases in soil crusting; decreases in the cover of cryptobiotic crusts; decreases in soil aggregate stability; and/or evidence of erosion, including water flow patterns and litter movement.

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. If the invasive or noxious species continue to thrive without mechanical, biological, or chemical control methods, the invasive nature of the weed will outcompete the present plant community. Once the invasive species reaches its maximum population level for this site, effective control is unlikely without massive resource inputs. Ecological processes at a site may change after an invading species has established and spread (Walker and Smith 1997).

Community 4.1
Invaded Community

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

State 5
Conifer Encroached State

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 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 trigger for transition is conifer tree encroachment that exceeds 2 stem per acre.

Community 5.1
Conifer Encroached Community

Rocky Mountain juniper (*Juniperus scopulorum*), ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*) encroachment is common 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. It is also noted that all states may transition to the Conifer Encroached State; however, encroachment is most likely to occur in the Altered State, where there is an increase in bare ground due to a combination of factors that allows seed-to-soil contact with reduced competition. Fire suppression and improper grazing management are the two most common triggers. The exact mode in which conifers begin to encroach varies; however, the trend points to a combination of 1 or more of the following: repeated moderately heavy to heavy grazing; reduced (non-existent) fire frequency; increased atmospheric carbon; and a 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 conifer encroachment are not immediately noticeable, but over time, as the conifer canopy increases, light and water interception increase, which reduces 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. Increased tree 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 juniper encroachment on these plant communities for an approved ecological site description. Studies (Miller et al., 2000) based in an area similar 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 Conifer Encroached Communities of Montana exhibit 3 or 4 different phases based, at this time, on qualitative experience. Phase I (Early) is defined by actively expanding juniper cover with generally less than 10 percent canopy cover and the trees' limbs generally touching the ground. This early stage generally has not completely lost its hydrologic functions, but 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 the risk of a dangerously hot fire is reduced. Phase II (Midphase) is still actively expanding, but canopy cover may reach 15–25 percent, and due to the more mature trees, seed production is very high. This Midphase begins to highly restrict herbaceous and shrubby plants, and junipers tend to be codominant. Hydrology is departing from reference, with rills becoming longer and, in isolated areas, erosional gullies possible. Control methods for the Midphase should focus on mechanical treatment, as there is a high risk of catastrophic and potentially sterilizing fire. Phase III (Late Phase) is where conifer cover exceeds 25 percent and has slowed as a forest condition. Lower tree limbs begin to die, and the shrub cover is nearly gone. Traveling through this community is increasingly difficult. Conifers become the dominant plant, with herbaceous plant production greatly decreasing. Bare ground increases, and hydrologic function is nearly lost compared to a grass or shrub community. Late 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. Because soil stability and hydrologic function are lacking in this phase, mechanical juniper removal will be required. Phase IV (Closed Phase) is the steady state forest, where the system is nearly devoid of rangeland plants. The trees stop producing seed and begin to close in on each other. This phase is impassable, and nearly all light and precipitation are intercepted. Bare ground is high, and soil chemistry slowly changes due to acidification from conifer needles. The closed phase is extremely rare in this LRU for two 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 that the historical plant community was rangeland, preventing misclassification of historic Juniper Forests (often more than 100 years old).

Transition T1A
State 1 to 2

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

Transition T1C
State 1 to 3

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

Transition T1B
State 1 to 4

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

Transition T1D
State 1 to 5

The transition from the Reference State (1) to the Conifer Encroached State (5) is driven primarily by long-term fire suppression but heavy grazing may contribute to increased bare ground for seeding sites. Encroachment often occurs fastest within 200 feet of the seed source. The trigger for transition is a conifer stem count higher than 2 per acre.

Restoration pathway R2A
State 2 to 1

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

Conservation practices

Prescribed Grazing

Transition T2A
State 2 to 3

As improper grazing management continues, the vigor of bunch grasses will decrease and the shorter grasses and shrubs will increase, leading to the Degraded Shortgrass State (3). Prolonged drought will provide a competitive advantage to shrubs, allowing them to become co-dominant with grasses. The canopy cover of shrubs will increase above 10%. Key transition factors include: an increase in native shrub canopy cover; a reduction in bunchgrass production; a decrease in total plant canopy cover and production; increases in mean bare patch size; increases in soil crusting; decreases in the cover of cryptobiotic crusts; decreases in soil aggregate stability; and/or evidence of erosion, including water flow patterns and litter movement.

Transition T2B
State 2 to 4

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

Transition T2C
State 2 to 5

The transition from the Altered State (2) to the Conifer Encroached State (5) is driven primarily by long-term fire suppression but long-term heavy grazing may contribute to increased bare ground for seeding sites. Encroachment often occurs fastest within 200 feet of the seed source. The trigger for transition is a conifer stem count higher than 2 stems per acre.

Restoration pathway R3B
State 3 to 1

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

Conservation practices

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

Restoration pathway R3A
State 3 to 2

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

Conservation practices

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

Transition T3A
State 3 to 4

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

Transition T3B
State 3 to 5

The transition from the Degraded State (3) to the Conifer Encroached State (5) is driven primarily by long-term heavy grazing and increased bare ground for seeding sites. Encroachment often occurs fastest within 200 feet of the seed source. The trigger for transition is a conifer stem count higher than 2 per acre

Restoration pathway R4C
State 4 to 1

Restoration of the Invaded State (4) to the Bunchgrass State (1) requires substantial energy input. The drivers for the restoration pathway are the removal of invasive species, restoration of native bunchgrass species, persistent management of invasive species, and proper grazing management. Without continued control, invasive species are likely to return (probably rapidly) due to the presence of seeds and/or other viable material in the soil and management-related practices that increase soil disturbance. If invaded by conifer encroachment, treatment depends on the condition of the rangeland. Sites that have transitioned from the Degraded State (3) to the Invaded State (4) may be severely lacking in soil and vegetative properties that will allow for restoration to the Bunchgrass State. Hydrologic function damage may be irreversible, especially with accelerated gully erosion.

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 Bunchgrass 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.

Restoration pathway R4A
State 4 to 3

If invasive species are removed, the site could return to the Degraded Shortgrass 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. Due to a lack of ground cover, the invading species cause a significant increase in soil loss (Lacey et al. 1989).

Transition T4A
State 4 to 5

The transition from the Invaded State (4) to the Conifer Encroached State (5) is driven primarily by long-term fire suppression but long-term heavy grazing may contribute to increased bare ground for seeding sites. Encroachment often occurs fastest within 200 feet of the seed source. The trigger for transition is a conifer stem count higher than 2 per acre.

Restoration pathway R5A

State 5 to 1

Restoration efforts may simply focus on the removal of coniferous trees and shrubs to restore the Conifer Encroached State (5) to the Bunchgrass State (1), depending on the level of conifer canopy cover and its impact on rangeland health. If following and utilizing the phases established by Miller et al., management and restoration methods will vary. A majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's phases. When conifers are removed through brush management and/or prescribed fire, Phase I may reveal none-to-slight to moderate deviations from rangeland health. 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 are suggested. In a short period of time, removing a Phase I encroachment will return the site to its original state. Proactive pest management is encouraged. Phase II encroachment may require a more intensive mechanical removal of trees and 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), increased rill frequency and length, and possibly more 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. The 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. Prior to any prescribed burning, forest management style tree removal (removal of woody debris and logs from the site) will be required to prevent the fire from burning too hot. The result of a prescribed fire on this site is typically unknown as seed sources of native herbaceous plants are usually limited to small patches. Since the Limy Droughty ecological site for 44B LRU 01 Subset A is a dry site, herbaceous plants will likely have been depleted under a Phase III encroachment. This means there is an opportunity for large areas of bare ground, increased rilling, 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 required to ensure the establishment of any new seedlings.

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 following and utilizing the phases established by Miller et al., management and restoration methods will vary. A majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's phases. When conifers are removed through brush management and/or prescribed fire, Phase I may show none-to-slight to moderate deviations from rangeland health. 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 are suggested. In a short period of time, removing a Phase I encroachment will return the site to its original state. Proactive pest management is encouraged. Phase II encroachment may require a more intensive mechanical removal of trees and 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), increased 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. The 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. Prior to any prescribed burning, forest management style tree removal (removal of woody debris and logs from the site) will be required to prevent the fire from burning too hot. The result of a prescribed fire on this site is typically unknown as seed sources of native herbaceous plants are usually limited to small patches. Since the Limy Droughty ecological site for 44B LRU 1 Subset A is a dry site, herbaceous plants will likely have been depleted under a Phase III encroachment. This means there is an opportunity for large areas of bare ground, increased rilling, 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 required to ensure the establishment of any new seedlings.

Restoration pathway R5C
State 5 to 3

The Conifer Encroached State (5) Phases I and II will generally resemble the Degraded State (2) on this site. If following and utilizing the phases established by Miller et al., management and restoration methods will vary. A majority of the conifer encroachment in MLRA 44B will fall into the early two phases of Miller's phases. When conifers are removed through brush management and/or prescribed fire, Phase I may show none-to-slight to moderate deviations from rangeland health. 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 are suggested. In a short period of time, removing a Phase I encroachment will return the site to its original state. Proactive pest management is encouraged. Phase II encroachment may require a more intensive mechanical removal of trees and 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), increased 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. The 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. Prior to any prescribed burning, forest management style tree removal (removal of woody debris and logs from the site) will be required to prevent the fire from burning too hot. The result of a prescribed fire on this site is typically unknown as seed sources of native herbaceous plants are usually limited to small patches. Since the Limy Droughty ecological site for 44B LRU 1 Subset A is a dry site, herbaceous plants will likely have been depleted under a Phase III encroachment. This means there is an opportunity for large areas of bare ground, increased rilling, 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 required to ensure the establishment of any new seedlings.

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Cool Season Bunchgrasses**			450–713	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	400–675	–
	needle and thread	HECO26	*Hesperostipa comata*	150–475	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	22–71	–
	green needlegrass	NAVI4	*Nassella viridula*	22–45	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–45	–
2	**Shortgrasses/Rhizomatous Grasses/Grasslikes**			60–94	
	plains reedgrass	CAMO	*Calamagrostis montanensis*	15–47	–
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	30–47	–
	western wheatgrass	PASM	*Pascopyrum smithii*	30–47	–
	Sandberg bluegrass	POSE	*Poa secunda*	30–47	–
	blue grama	BOGR2	*Bouteloua gracilis*	15–45	–
	needleleaf sedge	CADU6	*Carex duriuscula*	15–45	–
	threadleaf sedge	CAFI	*Carex filifolia*	15–45	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	30–45	–

	Grass, perennial	2GP	*Grass, perennial*	15–23	–
Forb					
3	**Forbs**			42–63	
	Forb, perennial	2FP	*Forb, perennial*	10–32	–
	fleabane	ERIGE2	*Erigeron*	21–31	–
	buckwheat	ERIOG	*Eriogonum*	21–31	–
	hairy false goldenaster	HEVI4	*Heterotheca villosa*	21–31	–
	desertparsley	LOMAT	*Lomatium*	21–31	–
	beardtongue	PENST	*Penstemon*	21–31	–
	spiny phlox	PHHO	*Phlox hoodii*	21–31	–
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	21–31	–
	American vetch	VIAM	*Vicia americana*	21–31	–
	ballhead sandwort	ARCO5	*Arenaria congesta*	15–25	–
	milkvetch	ASTRA	*Astragalus*	10–24	–
	Forb, annual	2FA	*Forb, annual*	0–10	–
Shrub/Vine					
4	**Shrubs**			48–76	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	24–38	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	0–38	–
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	15–38	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	21–38	–
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0–24	–
	Gardner's saltbush	ATGA	*Atriplex gardneri*	10–24	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–24	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–24	–
	black sagebrush	ARNO4	*Artemisia nova*	10–24	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–10	–

Table 10. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Cool Season Bunchgrasses**			421–675	
	needle and thread	HECO26	*Hesperostipa comata*	375–610	–
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	50–550	–
	green needlegrass	NAVI4	*Nassella viridula*	21–68	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	42–68	–
2	**Shortgrasses/Rhizomatous grasses/Grasslike**			56–90	
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	28–50	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	28–45	–
	Sandberg bluegrass	POSE	*Poa secunda*	28–45	–
	plains reedgrass	CAMO	*Calamagrostis montanensis*	28–45	–
	needleleaf sedge	CADU6	*Carex duriuscula*	28–45	–
	Grass, perennial	2GP	*Grass, perennial*	18–35	

	Grass, perennial	2GP	*Grass, perennial*	18–35	–
	threadleaf sedge	CAFI	*Carex filifolia*	18–30	–
	blue grama	BOGR2	*Bouteloua gracilis*	0–23	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–23	–
Forb					
3	**Forbs**			28–45	
	Forb, perennial	2FP	*Forb, perennial*	14–23	–
	ballhead sandwort	ARCO5	*Arenaria congesta*	10–22	–
	milkvetch	ASTRA	*Astragalus*	10–22	–
	fleabane	ERIGE2	*Erigeron*	14–22	–
	buckwheat	ERIOG	*Eriogonum*	14–22	–
	hairy false goldenaster	HEVI4	*Heterotheca villosa*	14–22	–
	desertparsley	LOMAT	*Lomatium*	14–22	–
	beardtongue	PENST	*Penstemon*	14–22	–
	spiny phlox	PHHO	*Phlox hoodii*	14–22	–
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	14–22	–
	American vetch	VIAM	*Vicia americana*	14–22	–
	Forb, annual	2FA	*Forb, annual*	0–10	–
Shrub/Vine					
4	**Shrubs**			56–90	
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	28–45	–
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	28–45	–
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	10–45	–
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	28–45	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	20–40	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–40	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–25	–
	black sagebrush	ARNO4	*Artemisia nova*	0–25	–
	Gardner's saltbush	ATGA	*Atriplex gardneri*	10–22	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–10	–

Animal community

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

The 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 Bluebunch Wheatgrass Community (1.1) is likely to have minimal sage grouse presence given its low sagebrush canopy cover. However, the potentially diverse forb component of the Bunchgrass 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 (the Needle and Thread Community), where big sagebrush populations are under a reduced fire regime. Also, as sagebrush canopy cover increases under Altered States 2.1 and 2.2 and, to a limited extent, under

Degraded State 3.1, pygmy rabbit, Brewer's sparrow, and mule deer use may also increase.

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

Since needle and thread normally matures earlier than bluebunch wheatgrass 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.

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

Continual 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 Bunchgrass 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 can degrade further to the Degraded Shortgrass State or the Invaded State. Management should focus on grazing management strategies that will prevent further degradation, such as seasonal grazing deferment or winter grazing where feasible. Communities within this state are still stable and healthy under proper management. Forage quantity and/or quality may be substantially decreased from the Bunchgrass 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 by invasive-dominant communities. 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 Bunchgrass State (1) with good infiltration and deep percolation of rainfall; however, the cycle degrades as the vegetation community declines. Rapid rainfall infiltration, high soil organic matter, good soil structure, and good porosity accompany a high bunchgrass canopy cover of around 80 percent. High ground cover reduces raindrop impact on the soil surface, which keeps erosion and sedimentation transport low. Water leaving the site will have 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 Bluebunch Wheatgrass Community (1.1) should have no rills or gullies present, and drainage ways should be vegetated and stable. Water flow patterns, if present, will be barely observable. Plant pedestals are essentially 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 Bluebunch Wheatgrass Community (1.1). Compared to the Bluebunch Wheatgrass Community (1.1), infiltration rates are slightly reduced and surface runoff is slightly higher.

In the Shortgrass Community (2.2), Degraded Shortgrass State (3), and the Invaded State (4), canopy and ground cover are greatly reduced compared to the Bunchgrass State (1), which impedes the hydrologic cycle. Infiltration will decrease and runoff will increase due to reduced ground cover, 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.

Recreational uses

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

Wood products

This site is not suitable for wood products.

Inventory data references

Information presented was derived from the site's Range Site Description (Limy Droughty 9 –14" 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).

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	Grant Petersen
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Date	11/02/2015
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%. Slopes greater than 20% rills may exist but will be limited and less than 1 foot.

2. **Presence of water flow patterns:** Water flow patterns are rare in the reference condition. If present, they are most likely to occur on steeper slopes (20%) and are inconspicuous, disconnected, and very short in length.

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

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Less than 25%

5. **Number of gullies and erosion associated with gullies:** No gullies present.

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

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

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Surface Stable with Stability Ratings of 4-6 (both under canopy and bare). Biotic crusts and or root mats may be present.

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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 medium fine granular to weak subangular blocky. A Horizon should be 2-4 inches thick with color, when wet, typically ranging in Value of 4 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.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Evenly distributed across the site, bunchgrasses improve infiltration while rhizomatous grass protects the surface from runoff forces. The Limy Droughty ecological site is well drained and has a high infiltration rate. An even distribution of mid stature grasses, ~70-75% of site production, cool season rhizomatous grasses 10% of site production along with a mix of shortgrass 5-15%, forbs and shrubs (1-10%).

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Not present.

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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: Mid-statured, cool season, perennial bunchgrasses

    Sub-dominant: Shortgrasses ≥ rhizomatous grasses > shrubs = perennial forbs

    Other:

    Additional:

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

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14. **Average percent litter cover (%) and depth (in):** Litter cover varies from approximately 30 to 40%; comprised of primarily herbaceous litter. Most litter is irregularly distributed on the soil surface and is not at a measurable depth.

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

production): Average annual production is 850. Low: 600 High 950 lbs per acre. Production varies based on effective precipitation and natural variability of soil properties for this ecological site.

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:** Non-native invasive species on this ecological site include: Dandelion (Taraxicum spp), Cheatgrass (Bromus techtorum), Field brome (Bromus arvensis), Spotted knapweed (*Centaurea stoebe*), Yellow toadflax (Linaria vulgaris), Leafy Spurge (*Euphorbia esula*).

    Native species with the ability to indicate degradation however species presence alone does not imply degradation: Sandberg bluegrass (*Poa secunda*), Big sagebrush (Artemisia tridentata), Spineless horsebrush (Tetradymia canescens), Broom snakeweed (Gutierrezia sarothrae), Rubber rabbitbrush (Ericameria nauseosa), Yellow rabbitbrush (Chrysothamnus viscidiflorus), Rocky Mountain Juniper (*Juniperus scopulorum*), Douglas fir (Psuedotsuga menziesii), Ponderosa pine (*Pinus ponderosa*)

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17. **Perennial plant reproductive capability:** In the reference condition, all plants are vigorous enough for reproduction either by seed or rhizomes in order to balance natural mortality with species recruitment. Density of plants indicates that plants reproduce at level sufficient to fill available resource.
