USDA Natural Resources
Conservation Service

Ecological site EX044B01A006
Claypan (Cp) LRU 01 Subset A

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General information

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

MLRA notes

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

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

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

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

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

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

LRU notes

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

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

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

Classification relationships

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

EPA Ecoregions of Montana, Second Edition (US EPA 2013)
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 (Cleland et al. 2007)
Domain: Dry
Division: M330 – Temperate Steppe Division – Mountain Provinces
Province: M332 –Middle Rocky Mountain Steppe – Coniferous Forest – Alpine Meadow
Section: M332D – Belt Mountains Section
M332E – Beaverhead Mountains Section
Subsection: M332Ej – Southwest Montana Intermontane Basins and Valleys
M332Dk – Central Montana Broad Valleys

Ecological site concept

The Claypan ecological site is an upland site formed from alluvium and is on nearly slopes. The site does not receive additional moisture from a water table or flooding. The soil is moderately deep to very deep. The surface of the site has less than five percent stone and is not skeletal, with less than 35 percent rock fragments in the 10 to 20-inch depth. The soil surface textures is from loam to clay loam. The site has a high clay increase with a natric or relic natric horizon within 20 inches of the soil surface. The argillic horizon may act as a root restricting layer.

Associated sites

EX044B01A001	**Clayey (Cy) LRU 01 Subset A** The Clayey ecological site occupies adjacent landscape position above the Claypan ecological site.
EX044B01A165	**Thin Claypan (TCp) LRU 01 Subset A** The Thin Claypan occupies the same landscape and is often adjacent to or intermixed with Claypan sites. The plant communities are very similar and will share similar state and transition models.

Similar sites

EX044B01A165	**Thin Claypan (TCp) LRU 01 Subset A** Thin Claypan ecological site occupies the same landscape and is often adjacent to or intermixed with Claypan sites. The plant communities are similar though the Thin Claypan ecological site will express reduced production and increased shrub cover. These sites will share similar state and transition models.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata* (2) *Sarcobatus vermiculatus*
Herbaceous	(1) *Pseudoroegneria spicata* (2) *Pascopyrum smithii*

Legacy ID

R044BA006MT

Physiographic features

The Claypan site exists on gently sloping (less than 15 percent slope) low hills near the valley bottom or on fan remnants.

Table 2. Representative physiographic features

Landforms	(1) Intermontane basin > Hill (2) Intermontane basin > Fan remnant
Flooding frequency	None
Ponding frequency	None
Elevation	4,500–6,500 ft
Slope	2–15%
Aspect	Aspect is not a significant factor

Climatic features

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

Table 3. Representative climatic features

Frost-free period (characteristic range)	47-92 days
Freeze-free period (characteristic range)	91-120 days
Precipitation total (characteristic range)	11-13 in
Frost-free period (actual range)	30-110 days
Freeze-free period (actual range)	70-132 days
Precipitation total (actual range)	9-14 in
Frost-free period (average)	78 days
Freeze-free period (average)	107 days
Precipitation total (average)	12 in

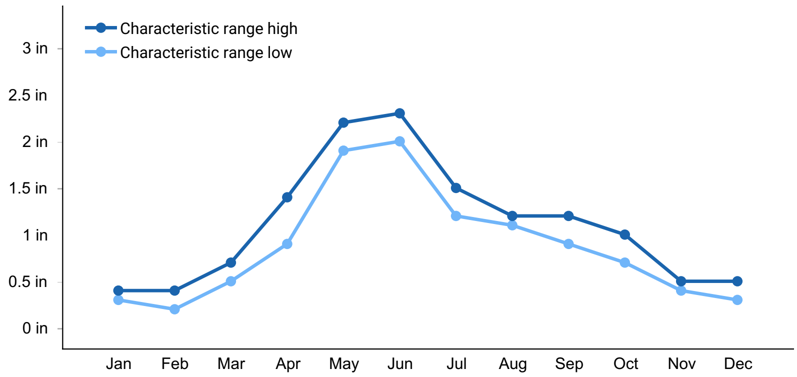


Figure 1. Monthly precipitation range

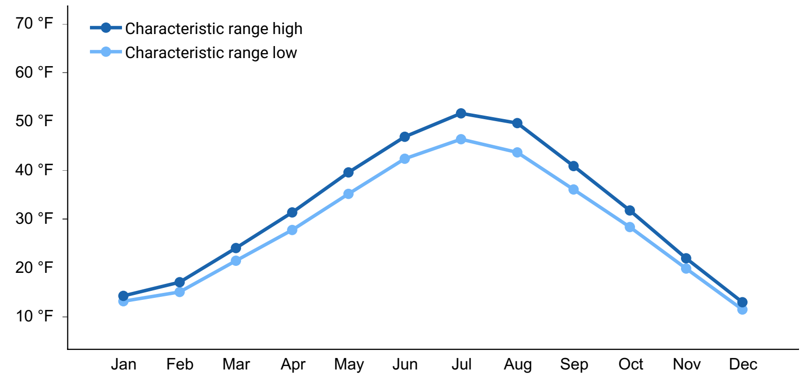


Figure 2. Monthly minimum temperature range

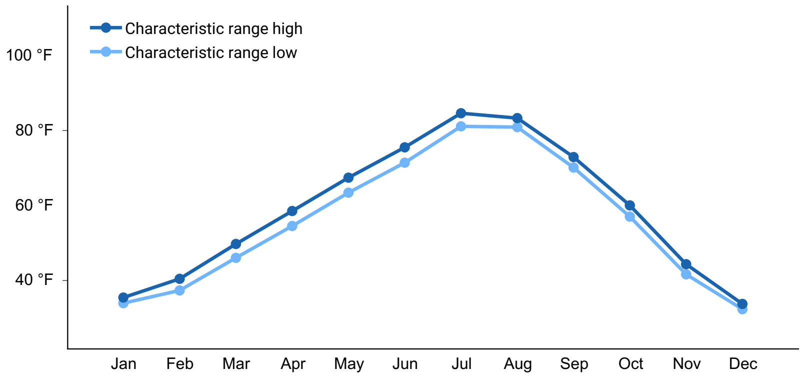


Figure 3. Monthly maximum temperature range

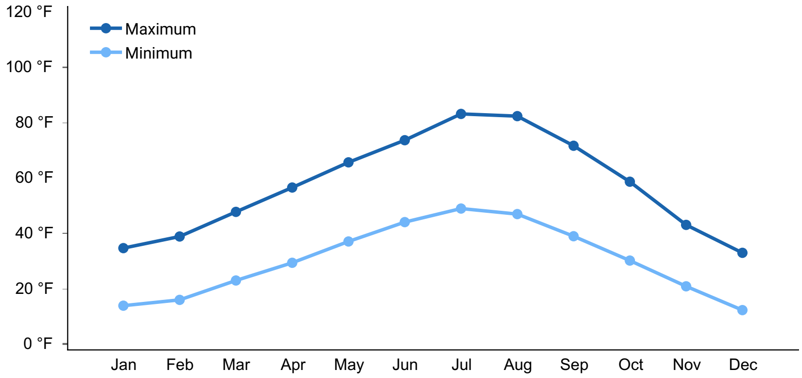


Figure 4. Monthly average minimum and maximum temperature

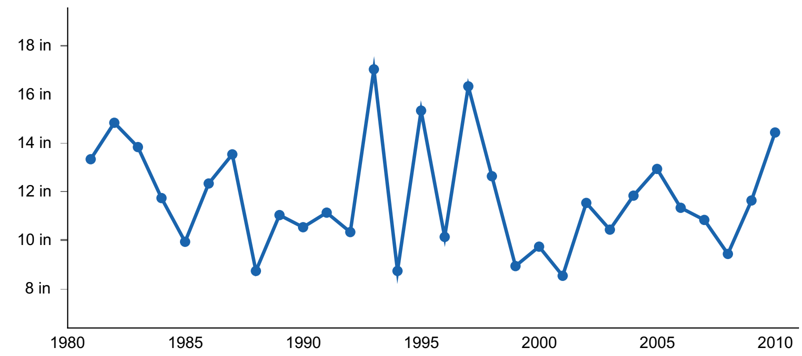


Figure 5. Annual precipitation pattern

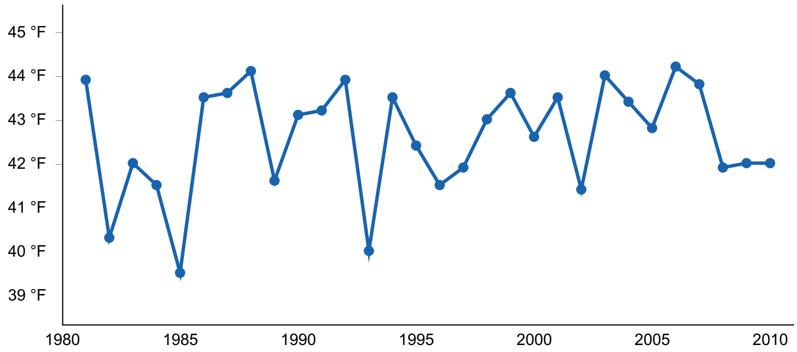


Figure 6. Annual average temperature pattern

Climate stations used

- (1) DILLION U OF MONTANA WESTERN [USC00242409], Dillon, MT
- (2) WHITE SULPHUR SPRNGS 2 [USC00248930], White Sulphur Springs, MT
- (3) DILLON AP [USW00024138], Dillon, MT
- (4) ALDER 17 S [USC00240110], Virginia City, MT
- (5) TOWNSEND [USC00248324], Townsend, MT
- (6) TRIDENT [USC00248363], Three Forks, MT
- (7) DEER LODGE 3 W [USC00242275], Deer Lodge, MT
- (8) HELENA RGNL AP [USW00024144], Helena, MT
- (9) TWIN BRIDGES [USC00248430], Sheridan, MT
- (10) ENNIS [USC00242793], Ennis, MT

Influencing water features

The site has a clay layer that slows infiltration. Runoff is high.

Wetland description

Site is not associated with wetland.

Soil features

This site exists on sedimentary originated soil with a high sodium (natric or relic natric) horizon, which has a columnar structure and an abrupt root or water-restrictive clay layer within 4 to 8 inches of the surface. As a result of this high clay layer, infiltration rates are slow. Clay content in the top four inches of soil is variable, however, an argillic horizon will have a significant increase in clay over the surface. Surface soil structure may range from fine granular to subangular blocky. An E horizon may be present, and if so, it will have a weak, platy structure. The structure of the clay layer will be columnar.

Common soil series include Deepone and Romnot. As these soils may express a range of characteristics, it is necessary to use the most current ecological site key with an onsite soil pit to determine the correct ecological site.

Table 4. Representative soil features

Parent material	(1) Alluvium–sedimentary rock
Surface texture	(1) Clay loam (2) Loam
Family particle size	(1) Fine
Drainage class	Well drained
Permeability class	Moderate to slow
Surface fragment cover <=3"	0–10%

Surface fragment cover >3"	0–1%
Available water capacity (0-40in)	4.9–8 in
Clay content (0-4in)	15–24%
Soil reaction (1:1 water) (0-10in)	6.4–9.4
Subsurface fragment volume <=3" (0-20in)	4–11%
Subsurface fragment volume >3" (0-20in)	0–1%

Ecological dynamics

The Claypan ecological site occurs in a relatively small landscape; however, slight variations within the plant community may exist due to elevation, frost-free days, and relative effective annual precipitation.

The Reference Community is dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyrum smithii*), and green needlegrass (*Nassella viridula*). Other species present are needle and thread (*Hesperostipa comata*), Sandberg bluegrass (*Poa secunda*), Wyoming big sage (*Artemisia tridentata* ssp. wyomingensis), winterfat (*Krascheninnikovia lanata*), and dotted blazing star (*Liatris punctata*). This potential is suggested by investigations showing a predominance of perennial grasses on near-pristine range sites (Ross et al., 1973). In the Reference State, shrubs comprise 10 to 15 percent of the community. This is higher than many other ecological sites in this MLRA.

The natural fire return interval was highly variable, reaching as high as 100 years; however, it was likely shorter than 35 years (Arno and Gruell 1982). Since 1910, there has been a significant increase in the suppression of fires in this system, resulting in a potential for increased sagebrush cover.

A shift to the dominance of shrubs may occur in response to improper grazing management, drought, or a reduced fire return interval. Within this site, shrub encroachment by a variety of species is evident, including broom snakeweed (*Gutierrezia sarothrae*), prairie sagewort (*Artemisia frigida*), Wyoming big sagebrush, rubber rabbitbrush (*Ericameria nauseosa*), and plains prickly pear (Opuntia polycantha). Shrub dominance and grass loss are associated with soil erosion and, ultimately, thinning of the native soil surface. Subsequent loss of soil could lead to a Degraded Shortgrass State. All states could also lead to the Invaded State when there is a lack of weed prevention and control measures.

Historical records indicate that, prior to the introduction of livestock (cattle and sheep) during the late 1800s, elk and bison grazed this ecological site. Due to bison's nomadic nature and herd structure, grazed areas received periodic high intensity, short duration grazing pressure. Livestock forage was noted as being minimal in areas recently grazed by bison (Lesica and Cooper 1997).

Meriwether Lewis documented that he was met by 60 Shoshone warriors on horseback in August 1805, and the Corps of Discovery was later supplied with horses by the same band of Shoshone. This suggests that the areas near the modern-day Montana towns of Twin Bridges, Dillon, Grant, and Dell were grazed by an untold number of horses for many years prior to the large introduction of cattle and sheep. The gold boom of the 1860s brought the first herds of livestock overland from Texas, and homesteaders began settling the area. During this time, cattle were the primary domestic grazers in the area. In the 1890s, sheep production increased by more than 400 percent and dominated the livestock industry until the 1930s. Since then, cattle production has dominated the livestock industry of the region (Hansen and Wyckoff 1991).

Lesser spikemoss (*Selaginella densa*), in general, is a minor component of the reference plant community of this ecological site. The conditions that created large cover classes of clubmoss on this site point to a history of continuous (yearlong) or moderate spring grazing use (Sturm 1954). In some situations, the site could be old crop fields that have reverted back to rangeland. In this case, spikemoss is helping reduce erosion and increase site stability. While dense clubmoss provides soil stability on sites where it exists, anecdotal observations suggest that it competes for the limited water resources in the upper soil profile, which restricts plant available water; however, a study from Canada in a similar climate on similar soils indicates that the correlation between reduced plant available water and clubmoss cover is negligible (Colberg and Romo 2003). The correlation between reduced plant production may simply be competition for space though quantitative evidence is unavailable at this time. Dense patches of spikemoss may inhibit seed contact with soil reducing seedling recruitment.

This ecological site is highly susceptible to invasion by nonnative grasses. Cheatgrass (Bromus techtorum) and field brome (*Bromus arvensis*) invasion is common. These plants are typically associated with nearby human impacts (roads and construction activities).

Plant Communities and Transitions
A state and transition model (STM) 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.

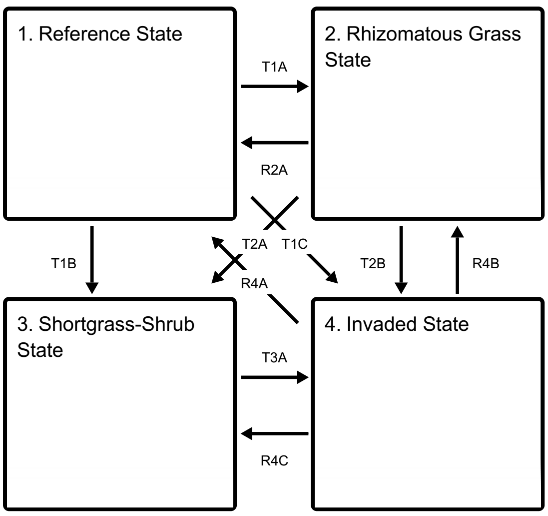
The plant communities within the same ecological site will differ across the MLRA due to the naturally occurring variability in weather, soils, and aspect. The biological processes on this site are complex; therefore, representative values are presented in a land management context. The species lists 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.

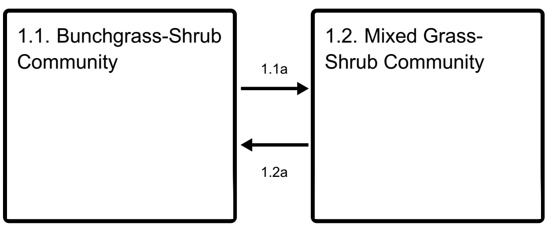
Although there is considerable qualitative experience supporting the pathways and transitions within the STM, no quantitative information exists that specifically identifies threshold parameters between grassland types and invaded types in this ecological site.

State and transition model

Ecosystem states



State 1 submodel, plant communities



State 2 submodel, plant communities

2.1. Rhizomatous Community

State 3 submodel, plant communities

3.1. Shortgrass-Shrub Community

State 4 submodel, plant communities

4.1. Annual Grass Invaded Community

State 1
Reference State

Reference State consists of two plant communities. The first is dominated by deep-rooted bunchgrasses and rhizomatous grasses. The second community is co-dominated by bunchgrasses, shrubs and rhizomatous grasses. These communities regularly transition in response to varying climatic conditions and minor disturbances. The Reference State exists where grazing by livestock and wildlife has historically been light to moderate and grazing events have been short. This reduces the opportunity for grazing regrowth and maintains.

Community 1.1
Bunchgrass-Shrub Community

The Bunchgrass-Shrub Community is characterized by a plant community dominated by bluebunch wheatgrass, green needlegrass, western wheatgrass, and Wyoming big sagebrush. This community is considered the Reference Community for this ecological site. Other species on this site are similar to others in this climate regime and include black greasewood, Gardner's saltbush, low sagebrush, scarlet globemallow, prairie Junegrass, and Sandberg bluegrass. 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 Reference State 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.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	439	640	839
Shrub/Vine	83	120	158
Forb	28	40	53
Total	**550**	**800**	**1050**

Table 6. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	1-5%
Grass/grasslike basal cover	5-10%
Forb basal cover	1-3%
Non-vascular plants	0%
Biological crusts	0.0-0.1%
Litter	15-25%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	15-30%

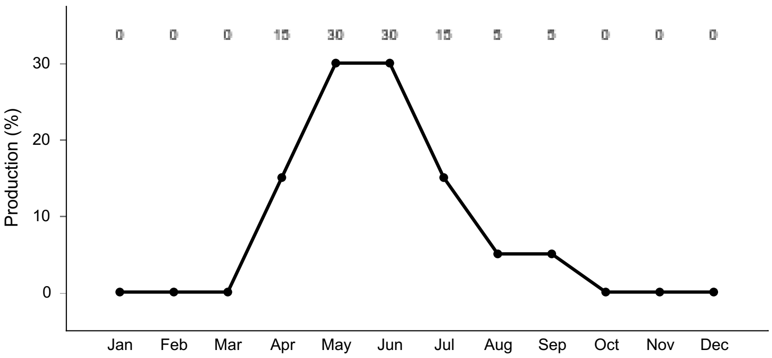


Figure 8. Plant community growth curve (percent production by month). MT44B032, Dry Uplands. Cool season grass dominated system. Most dry, upland sites located within MLRA 44B LRU A are characterized by early season growth which is mostly complete by Mid-July. Limited fall "green-up" if conditions allow..

Community 1.2
Mixed Grass-Shrub Community

The Mixed Grass-Shrub Community is a community that contains nearly equal proportions of bluebunch wheatgrass and western wheatgrass as dominant species, with a slight increase in Wyoming big sagebrush. Western wheatgrass tolerates grazing pressure better than bluebunch wheatgrass and green needlegrass. The growing point for bluebunch wheatgrass grass is several inches above the ground, making it very susceptible to continued close grazing (Smoliack, et al 2006) while western wheatgrass growing points tend to be near the plant base. Western wheatgrass and Sandberg bluegrass increase in species composition when more palatable and less grazing tolerant plants decrease due to improper grazing management. Western wheatgrass and bluebunch wheatgrass share dominance in the Mixed Grass-Shrub Community (1.2) with green needlegrass being rare. Other grass species, which are more tolerant to grazing and are likely to increase in number compared to the Bunchgrass-Shrub Community, include Sandberg bluegrass (*Poa secunda*), prairie Junegrass, and blue grama (*Bouteloua gracilis*). Hood's phlox (*Phlox hoodii*), scarlet globemallow (*Sphaeralcea coccinea*), false hairy goldenaster (*Heterotheca villosa*), and pussytoes (Antennaria spp.) are examples of increaser forb species common to this site. Prairie 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 and litter. 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 is still a dominant species of total biomass production, the site can return to the Bunchgrass-Shrub Community (Pathway 1.2A) under proper grazing management and favorable growing conditions. Western wheatgrass will continue to increase until they make up the majority of species composition. Once bluebunch wheatgrass has been reduced to less than 25 percent dry weight it may be difficult for the site to recover to Bunchgrass-Shrub 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 returning to the Bunchgrass-Shrub Community (1.1). The Mixed Grass-Shrub 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 dominate and this triggers the change to the Rhizomatous State (2) or the Shortgrass-Shrub State (3). Until the Mixed Grass-Shrub Community (1.2) crosses the threshold into the Rhizomatous Community (2.1) or the Invaded Community (4.1), this community can be managed toward the Bunchgrass-Shrub 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.

Pathway 1.1a
Community 1.1 to 1.2

Bluebunch wheatgrass loses vigor with improper grazing or extended drought. When vigor declines enough for plants to die or become smaller, species with higher grazing tolerance (in this ecological site, they are western and thickspike wheatgrass) increase in vigor and production as they access the resources previously used by bluebunch wheatgrass. The decrease in species composition by weight of bluebunch wheatgrass to less than 25 percent indicates that the plant community has shifted to the Mixed Grass-Shrub 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. Drought and warmer-than-normal temperatures are known to advance plant phenology by as much as one month (Blaisdell 1958). During drought years, plants may be especially sensitive or reach a critical stage of development earlier than expected.

Pathway 1.2a
Community 1.2 to 1.1

The Mixed Grass-Shrub Community (1.2) will return to the Bunchgrass-Shrub Community (1.1) with proper grazing management and appropriate grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. It will take several years of favorable conditions for the community to transition back to a bluebunch dominated state. The driver for this community shift (1.2a) is the increased vigor of bluebunch wheatgrass, to the point that it represents more than 25 percent of species composition. The trigger for this shift is the change in grazing management favoring bluebunch wheatgrass. These triggers are generally conservative grazing management styles such as deferred or rest rotations utilizing light to moderate grazing (less than 50 percent use) combined with favorable growing conditions such as cool, wet springs. 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 stable may not result in an increase in bluebunch wheatgrass, and it is suggested 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 (Noy-Meir 1975).

State 2
Rhizomatous Grass State

This state is characterized by having less than 10 percent bluebunch wheatgrass by dry weight. It is represented by one community. 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. This may include western wheatgrass, needle and thread, Sandberg bluegrass, scarlet globemallow, hairy false goldenaster, and prairie sagewort.

Community 2.1
Rhizomatous Community

Long-term grazing mismanagement with continuous growing season pressure will reduce the total productivity of the site and lead to an increase in bare ground. 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 Rhizomatous Grass State (2) because it creates a threshold requiring energy input to return to the Reference State (1). Transition to the Rhizomatous Community (2.1) may be exacerbated by extended drought conditions. Western wheatgrass dominates the Rhizomatous Community (2.1). 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. Invasive species will become more common. Hairy false goldenaster, pussytoes, and scarlet globemallow are examples of increaser forbs. It is not uncommon for a minor component of invader species such as dandelion and yellow salsify (*Tragopogon dubius*) to be present, though at a level not high enough to be considered for transition to the Invaded State (4). This creates more competition for bluebunch wheatgrass and makes it difficult for bluebunch wheatgrass to quickly respond to a change in grazing management alone. Therefore, an input of energy is required for the community to return to the Reference State (1). Wind and water erosion may be eroding soil from the plant interspaces. Soil fertility is reduced, and soil surface erosion resistance has declined compared to the Reference State (1). This community crossed a threshold compared to the Mixed Grass-Shrub 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. Under decreased grazing pressure, a needle and thread/blue grama plant community did not change species composition, but the content of the soil carbon increased (Dormaar et al. 1997). 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. Continued improper grazing will drive the community into a Shortgrass-Shrub State (3). Introduction or expansion of invasive species will further drive the plant community to the Invaded State (4).

State 3
Shortgrass-Shrub State

Shortgrass-Shrub State lacks midstatured bunchgrasses. Western wheatgrass, blue grama, Sandberg bluegrass, and prairie Junegrass are dominant grasses. Increasers like broom snakeweed and prickly pear cactus are almost as productive as the larger sagebrush shrubs. Larger shrub species that remain are heavily hedged. This state will be treated as a terminal state (e.g., restoration will likely be impossible or unsuccessful and require major energy inputs).

Community 3.1
Shortgrass-Shrub Community

In response to multiple, and often concurrent, disturbance events (overgrazing, continued drought, extreme fire, etc) deep-rooted grasses, forbs, and shrubs are removed and replaced with shallow-rooted plants. The result is an unstable site that is highly susceptible to erosion as well as invasion by nonnative species, particularly annual grasses. Plant production is extremely limited and often too low to be economically valuable for grazing livestock.

State 4
Invaded State

The Invaded State is identified by being in the exponential growth phase of invader species where control is a priority. Dominance (or relative dominance) of noxious/invasive species reduces species diversity, forage production, wildlife habitat, and site protection. A level of 10 percent invasive species composition by dry weight indicates the point that a substantial energy input will be required to create a shift to a 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 species composition of invasive species.

Community 4.1
Annual Grass Invaded Community

Communities in this state may be structurally indistinguishable from any of the communities in States 1 through 3, except that annual grasses exceed 10 percent of species composition by dry weight. The Reference State has low resistance to invasion by annual grasses; however, especially hot and dry conditions and/or a hot fire may allow annuals to establish. For aggressive invasive species such as cheatgrass, 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 in the early stages of invasion, 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. 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 annual bromes become established, they become very difficult to eradicate. Therefore, considerable effort should be placed into 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).

Transition T1A
State 1 to 2

The Reference State (1) transitions to the Rhizomatous Grass State (2) if bluebunch wheatgrass, by dry weight, decreases to below 10 percent by weight or if bare ground cover is increased beyond 20 percent. The driver for this transition is the 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 Rhizomatous Grass State. There are several other key factors signaling the approach of transition T1A: increases in soil physical crusting, decreases in the cover of cryptogamic crusts, decreases in soil surface aggregate stability, and/or evidence of erosion, including water flow patterns, the 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 composition to less than 10 percent by weight and a reduction in total plant canopy cover.

Transition T1B
State 1 to 3

The Reference State (1) transitions to the Shortgrass-Shrub State (3) when bluebunch wheatgrass is removed from the plant community. Needle and thread is subdominant to short-statured bunchgrasses such as Sandberg bluegrass. The trigger for this transition is the loss of taller bunchgrasses, which creates open spaces with bare soil. Soil erosion results in decreased soil fertility, driving transitions to the Shortgrass-Shrub State. There are several other key factors signaling the approach of transition T1B: increases in soil physical crusting, decreases in the cover of cryptogamic crusts, decreases in soil surface aggregate stability, and/or evidence of erosion, including water flow patterns, the development of plant pedestals, and litter movement. The drivers for this transition are improper grazing management, intense or repeated fires, and/or heavy human disturbance. Rapid transition is generally realized when 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 by 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. The species composition by dry weight of invasive species approaches 10 percent.

Restoration pathway R2A
State 2 to 1

The Rhizomatous Grass State (2) has lost soil or vegetation attributes to the point that recovery to the Reference State (1) may 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. Prescribed grazing tactics may include a rest or deferred-season rotation with light or moderate grazing intensity. 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. Fire should be carefully planned or avoided in areas prone to annual grass infestation. The drivers for this restoration pathway are reclamation efforts and proper grazing management.

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 towards the Shortgrass-Shrub State (3). Prolonged drought will provide a competitive advantage to shrubs, allowing them to become co-dominant with grasses. The shrub canopy will increase. 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 Rhizomatous Grass State (2) and drive it to the Invaded State (4). This state is at risk if invasive seeds and/or other viable materials 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 T3A
State 3 to 4

Invasive species can occupy the Shortgrass-Shrub State (3) and drive it to the Invaded State (4). The Shortgrass-Shrub 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 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 and cheatgrass. This transition could be assisted by overgrazing (failure to adjust stocking rate to declining forage production), a long-term lack of fire, or an extensive drought.

Restoration pathway 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 the site has transitioned from the Reference State to the Invaded State, the amount of time and resources necessary to transition back to the Reference State may be less than for a site that transitioned from the Rhizomatous Grass State. Sites that transitioned from the Rhizomatous Grass State (2) will require more inputs to reestablish native bunchgrasses before they will resemble the Reference State (1). Sites that have transitioned from the Shortgrass-Shrub State (3) to the Invaded State (4) may be severely lacking in soil and vegetative properties that will allow for restoration to the Reference 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 bunchgrass have been drastically reduced, the Invaded State (4) can return to the Rhizomatous Grass 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 R4C
State 4 to 3

If invasive species are removed, the site could return to the Shortgrass-Shrub 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 increase in soil loss due to a lack of ground cover (Lacey et al. 1989).

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Deep-rooted bunchgrasses**			320–360	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	180–220	10–30
	needle and thread	HECO26	*Hesperostipa comata*	65–100	5–15
	green needlegrass	NAVI4	*Nassella viridula*	40–60	5–10
	squirreltail	ELEL5	*Elymus elymoides*	0–20	0–5
2	**Rhizomatous grasses**			200–240	
	western wheatgrass	PASM	*Pascopyrum smithii*	140–180	5–10
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	60–80	3–5
	plains reedgrass	CAMO	*Calamagrostis montanensis*	0–20	0–2
3	**Increaser Bunchgrass/Shortgrasses**			80–120	
	Sandberg bluegrass	POSE	*Poa secunda*	45–55	3–5
	prairie Junegrass	KOMA	*Koeleria macrantha*	20–40	0–5
	blue grama	BOGR2	*Bouteloua gracilis*	10–20	0–3
	saltgrass	DISP	*Distichlis spicata*	0–15	0–1
	needleleaf sedge	CADU6	*Carex duriuscula*	5–10	0–1
Shrub/Vine					
4	**Shrubs**			40–150	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	40–120	5–15
	greasewood	SAVE4	*Sarcobatus vermiculatus*	0–20	0–5
	little sagebrush	ARAR8	*Artemisia arbuscula*	0–20	0–2
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0–10	0–1
	prairie sagewort	ARFR4	*Artemisia frigida*	0–10	0–1
	Gardner's saltbush	ATGA	*Atriplex gardneri*	0–5	0–1
	slender buckwheat	ERMI4	*Eriogonum microthecum*	0–5	0–1
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–1	0–1
Forb					
5	**Forbs**			40–80	
	American vetch	VIAM	*Vicia americana*	10–20	0–1
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	5–10	0–1
	bastard toadflax	COUM	*Comandra umbellata*	5–10	0–1
	pussytoes	ANTEN	*Antennaria*	5–10	0–1
	spiny phlox	PHHO	*Phlox hoodii*	5–10	0–1
	milkvetch	ASTRA	*Astragalus*	0–10	0–1
	desertparsley	LOMAT	*Lomatium*	5–10	0–1
	woolly plantain	PLPA2	*Plantago patagonica*	0–1	0

Animal community

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

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

Greater sage grouse may be present on sites with suitable habitat, typically requiring a minimum of 15 percent sagebrush canopy cover (Braun et al. 1977). The Bunchgrass-Shrub Community (1.1) is likely to have optimal sage grouse presence given its high sagebrush canopy cover. The potentially diverse forb component of the Reference State may also provide important early-season (spring) foraging habitat for the greater sage grouse and their broods. Other communities on the site with sufficient sagebrush cover may harbor sage grouse populations, specifically Rhizomatous Community 2.1, where big sagebrush populations are under a reduced fire regime. Also, as sagebrush canopy cover increases under the Rhizomatous Community and, to a limited extent, under Shortgrass-Shrub State 3.1, pygmy rabbit, Brewer's sparrow, and mule deer use may also increase.

Managed livestock grazing is suitable on this site due to the potential to produce an abundance of high-quality forage. In order to maintain the productivity of the site, grazing on this site must be managed carefully to make sure utilization is not excessive. Management objectives should include the maintenance or improvement of the native plant community. Careful management of the timing and duration of grazing is important. Short grazing periods and adequate deferment during the growing season are recommended for plant maintenance, health, and recovery. Early-season defoliation of bluebunch wheatgrass can result in high mortality and reduced vigor in plants (McLean and Wikeem 1985). They also suggest, based on prior studies, that regrowth is necessary before dormancy to reduce injury to 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 and Holmgren 1984).

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

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

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

Grazing is possible in the Invaded State. Invasive species are generally less palatable than native grasses. Forage production is typically greatly reduced in this state. Due to the aggressive nature of invasive species, sites in the Invaded State face an increased risk of further degradation by invasive-dominant communities. Grazing must be carefully managed to avoid further soil loss and degradation. Prescribed grazing can be used to manage invasive species. In some instances, carefully targeted grazing (sometimes in combination with other treatments) can reduce or maintain the species composition of invasive species.

Hydrological functions

The hydrologic cycle functions best in the 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 (Thurow et al. 1986). 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 Reference State should have very few rills and no 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.

In the Rhizomatous Grass State (2), the Shortgrass-Shrub State (3), and the Invaded State (4), canopy and ground cover are lower than in the Reference 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. (McCalla et al., 1984)

Recreational uses

This site provides some limited 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

The information contained within this ecological site description has been obtained from field observations, historic data, and professional judgement. Inventory sites are located across Southwest Montana.

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.

Braun, C.E., T. Britt, and R.O. Wallestad. 1977. Guidelines for Maintenance of Sage Grouse Habitats. Wildlife Society Bulletin (1973-2006) 5:99–106.

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.

Cleland, D.T., J.A. Freeouf, J.E. Keys, G.J. Nowacki, C. Carpenter, and W.H. McNab. 2007. Ecological Subregions: Sections and Subsections of the Coterminous United States. USDA Forest Service, General Technical Report WO-76. Washington, DC. 1–92.

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.

Dormaar, 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.

Hansen, K. and W. Wyckoff. 1991. Settlement, Livestock Grazing and Environmental Change in Southwest Montana, 1860–1990. Environmental History Review 15:45–71.

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.

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

Schoeneberger, P.J. and D.A. Wysocki. 2017. Geomorphic Description System, Version 5.0..

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

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

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

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

Sturm, J.J. 1954. A study of a relict area in Northern Montana. University of Wyoming, Laramie 37.

Thurow, T.L., Blackburn W. H., and L.B. Merrill. 1986. Impacts of Livestock Grazing Systems on Watershed. Page in Rangelands: A Resource Under Siege: Proceedings of the Second International Rangeland Congress.

US EPA. 2013. EPA Ecoregions of North America. Map, II edition. U.S. Environmental Protection Agency - National Health and Environmental Effects Research Laboratory, Corvallis, Oregon.

Various NRCS Staff. 2013. National Range and Pasture Handbook.

Walker, L.R. and S.D. Smith. 1997. Impacts of invasive plants on community and ecosystem properties. Pages 69–

86 in Assessment and management of plant invasions. Springer, New York, NY.

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.

Approval

Kirt Walstad, 9/08/2023

Rangeland health reference sheet

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

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Date	05/10/2020
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.

2. **Presence of water flow patterns:** Water flow patterns are rarely present except after heavy rainfall events. If present, flow patterns will be short (less than 2 feet in length).

3. **Number and height of erosional pedestals or terracettes:** Pedestals are not evident in the reference condition.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is 10 to 15 percent. It consists of small, randomly scattered patches.

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

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

7. **Amount of litter movement (describe size and distance expected to travel):** Litter movement is not evident in the reference condition.

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 4-5 under plant canopies and 3-4 in plant interspaces. The A horizon thickness is highly variable and is 2-8 inches thick.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil Structure at the surface is medium granular. A Horizon should be 2-8 inches thick with color, when wet, typically ranging in Value of 4 or less and Chroma of 2 or less.
Local geology may affect color, it is important to reference the Official Series Description (OSD) for characteristic range.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Infiltration of the Clay Pan ecological site is slow to very slow. The site is well drained. An even distribution of mid stature bunchgrasses (40 percent), rhizomatous grass (35 percent), cool season shortgrasses (10-15 percent), forbs (1-5 percent), and shrubs (5-15 percent) optimizes infiltration and reduces runoff under normal moisture events.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** A compaction layer is not present in the reference condition. The soil profile will contain an abrupt transition to an argillic horizon, which can be misinterpreted as compaction; however, the soil structure will be strong, medium subangular blocky, while a compaction layer will be platy or structureless (massive).

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 (bluebunch wheatgrass, green needlegrass) > rhizomatous grasses

    Sub-dominant: shortgrass grasses/grasslikes (blue grama, prairie Junegrass) ≥ shrubs > forbs

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Mortality in herbaceous species is not evident. Species with bunch growth forms may have some natural mortality in centers is 3 percent or less.

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14. **Average percent litter cover (%) and depth (in):** Total litter cover is 20 to 25 percent. 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 800lbs/acre (713kg/ha)
Low: 550lbs/acre (490kg/ha)
High 1050lbs/acre (1177kg/ha)
Production varies based on effective precipitation and natural variability of soil properties for this ecological site.

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:** Potential invasive (including noxious) species (native and non-native). Invasive species on this ecological site include (but are not limited to) annual brome spp., spotted knapweed, crested wheatgrass, pale madwort, and field pennycress (fanweed).
Native species such as broom snakeweed, Sandberg bluegrass, blue grama, pricklypear cactus, black greasewood, etc., when their populations are significant enough to affect ecological function, indicate site condition departure.

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