Ecological site EX044B01A036 Droughty (Dr) 10-14" PZ Frigid

Last updated: 2/11/2025
Accessed: 08/09/2026

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 Droughty ecological site is an upland site formed from alluvium or slope alluvium and is on slopes less than 15 percent. The site does not receive additional moisture from a water table or flooding. Soil surface texture are from sandy loam to clay loam in top 4 inches of soil with clay percentage less than 32 percent. 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 cover. This ecological site is skeletal, with greater than 35 percent rock fragments in the 10 to 20-inch depth. The site does not have a saline or saline-sodic influence and is not strongly or violently effervescent within four inches of the mineral surface. Calcium carbonates may increase with depth.

Associated sites

EX044B01A031	**Limy Droughty (LyDr) 10-14" PZ Frigid** Limy site occupies the same general landscape as Droughty ecological site.
EX044B01A136	**Shallow Loamy (SwLo) 10-14" PZ Frigid** Shallow to Gravel tends to occupy linear concave areas adjacent to Droughty site.
EX044B01A036	**Droughty (Dr) 10-14" PZ Frigid** Droughty steep site is in an adjacent landscape with slopes exceeding 15 percent.

Similar sites

EX044B01A032	**Loamy (Lo) 10-14" PZ Frigid** The Loamy ecological site differs in that it is not skeletal within the 10 to 20 inch control section. Production within this climate subset will be slightly higher on the Loamy ecological site.
EX044B01A030	**Limy (Ly) 10-14" PZ Frigid** The Limy ecological site differs by being not skeletal and is strong to violently effervescent in the surface 4 inches. The plant communities on these two sites will be similar however amounts and proportions of plant species will be different.
EX044B01A138	**Shallow Droughty (SwDr) 10-14" PZ Frigid** The Shallow Droughty ecological site differs in the soils is less than 20 inches deep to root restriction. Plant production on the Shallow Droughty ecological site is less than the Droughty site.
EX044B01A031	**Limy Droughty (LyDr) 10-14" PZ Frigid** The Limy Droughty site differs in that it is strongly or violently effervescent in the surface four inches. Site typically has lower production and more bare ground.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Artemisia tridentata* (2) *Tetradymia canescens*
Herbaceous	(1) *Pseudoroegneria spicata* (2) *Hesperostipa comata*

Legacy ID

R044BA036MT

Physiographic features

This ecological site occurs on slopes ranging from 1 to less than 15 percent; however, the core slopes of this ecological site exist in the 4 to 10 percent range. The Droughty ecological site exists on fan remnants, fan piedmont, escarpments, and hillslopes.

Table 2. Representative physiographic features

Landforms	(1) Intermontane basin > Fan remnant (2) Intermontane basin > Fan piedmont (3) Intermontane basin > Escarpment (4) Intermontane basin > Hillslope
Elevation	1,430 – 1,980 m
Slope	0 – 10 %
Water table depth	110 cm
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Elevation	Not specified
Slope	0 – 20 %
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 01 Subset 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)	230-360 mm

Frost-free period (actual range)	70-110 days
Freeze-free period (actual range)	110-140 days
Precipitation total (actual range)	230-360 mm
Frost-free period (average)	80 days
Freeze-free period (average)	130 days
Precipitation total (average)	310 mm

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

Influencing water features

This ecological site is an upland site not associated with current water features.

Wetland description

This site is not associated with wetlands.

Soil features

These soils range in depth from moderate to very deep, have a moderately slow to moderately rapid permeability, and are well drained. These soils are formed from alluvium and slope alluvium. The soil consists of loamy-skeletal soil, which is defined as averaging 35 percent or greater rock fragments by 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, but may also include clay loams. Soils are also typically gravelly. The common soil series in this ecological site are Geohrock and Coyoteflats. 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.

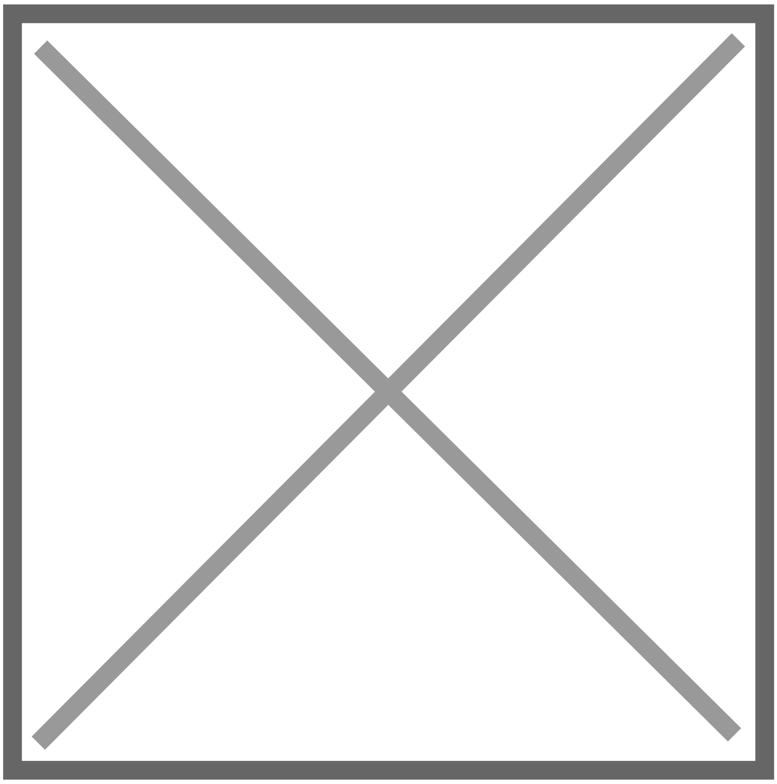

Figure 7.

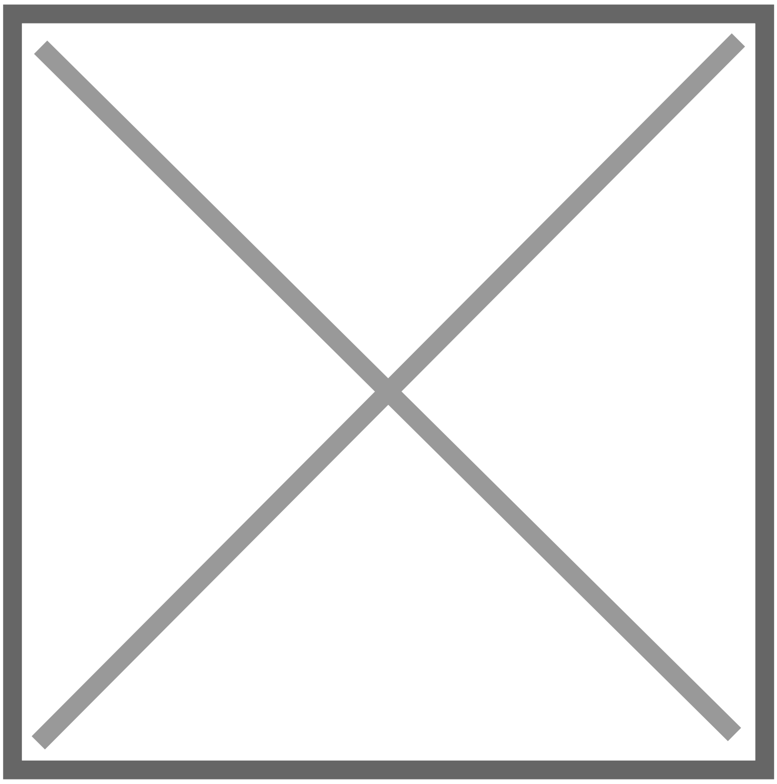

Figure 8.

Table 5. Representative soil features

Parent material	(1) Alluvium – igneous, metamorphic and sedimentary rock (2) Slope alluvium – igneous, metamorphic and sedimentary rock
Drainage class	Moderately well drained to well drained

Depth to restrictive layer	50 cm
Surface fragment cover <=3"	0 – 30 %
Surface fragment cover >3"	0 – 20 %

Ecological dynamics

The Droughty (Dr) ecological site reference plant community (like most ecological sites in LRU 01 Subset A) is dominated by bluebunch wheatgrass (Pseudoroegneria spicata) and needle and thread (Hesperostipa comata). Subdominant species include Wyoming big sagebrush with thickspike wheatgrass (Elymus lanceolatus) and green needlegrass (Nassella viridula). 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 Droughty ecological site occurs across a relatively large landscape, with slight variations within the plant community occurring due to elevation, frost-free days, and relative effective annual precipitation. The slight variations tend to change the numbers of individual species, but the core species community is rarely altered.

This ecological site is largely intact and is primarily used for livestock grazing. Historical records indicate that, prior to the introduction of livestock (cattle and sheep) during the late 1800s, elk and bison grazed this ecological site. Grazed areas received periodic high intensity, short duration grazing pressure due to bison's nomadic nature and herd structure. 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).

Dense clubmoss (Selaginella densa), in general, is a minor component of the reference plant community of the Loamy 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, clubmoss is helping reduce erosion and increase site stability, especially where livestock use is restricted (such as in CRP). While dense clubmoss provides soil stability on sites where it exists, anecdotal evidence suggests that it competes for the limited water resources in the upper soil profile, which restricts plant-available water. However, a study from Canada (Colberg and Romo 2003) in a similar climate on similar soils indicates that the correlation between reduced plant-available water and clubmoss cover is negligible. Although quantitative evidence is lacking, the correlation between reduced plant production and competition for space may simply be due to reduced plant production. Dense patches of clubmoss also inhibit seed contact with the soil, reducing seedling recruitment. Due to the scarcity of data on the relationship between clubmoss and the loamy ecological site in MLRA 44B, more research is required before considering creating its own state within the state and transition modeling so that this community is included in the invading state.

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 tectorum), field brome (Bromus arevensis), yellow toadflax (Linaria vulgaris), and dandelion (Taraxicum spp.). Invasive weeds are beginning to have a high impact on this ecological site due to primarily human impacts, mismanaged grazing, and urban development. Cheatgrass poses the largest threat to this ecological site.

Plant Communities and Transitional Pathways
A state and transition model for the Droughty ecological site are depicted in Figure 1. 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. Most observers find it easier to visualize or estimate the percent canopy for woody species (trees and shrubs). Canopy cover drives the transitions between communities and states because of the influence of shade, the interception of rainfall, and the competition for available water. Species composition by dry weight remains an important descriptor of the herbaceous community and of the community as a whole. Woody species are included in the species composition for the site. Calculating the similarity index requires species composition by dry weight.

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

Although there is considerable qualitative experience supporting the pathways and transitions within the 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

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
Grass/Grasslike					
1				690-1215	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	407-1001	–
	needle and thread	HECO26	*Hesperostipa comata*	168-358	–
	green needlegrass	NAVI4	*Nassella viridula*	56-214	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0-137	–
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	40-137	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	8-68	–
	Sandberg bluegrass	POSE	*Poa secunda*	8-68	–
	needleleaf sedge	CADU6	*Carex duriuscula*	8-50	–
	threadleaf sedge	CAFI	*Carex filifolia*	4-50	–
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	0-34	–
	blue grama	BOGR2	*Bouteloua gracilis*	0-34	–
	plains reedgrass	CAMO	*Calamagrostis montanensis*	8-34	–
	foxtail barley	HOJU	*Hordeum jubatum*	0-13	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0-11	–
	Grass-like, perennial	2GLP	*Grass-like, perennial*	0-11	–
	Grass, perennial	2GP	*Grass, perennial*	0-11	–
Forb					
2				40-71	
	dotted blazing star	LIPU	*Liatris punctata*	15-71	–
	hairy false goldenaster	HEVI4	*Heterotheca villosa*	4-71	–
	stiffleaf penstemon	PEAR2	*Penstemon aridus*	15-71	–
	spiny phlox	PHHO	*Phlox hoodii*	0-71	–
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	4-71	–
	American vetch	VIAM	*Vicia americana*	15-71	–
	bastard toadflax	COUM	*Comandra umbellata*	4-45	–
	desertparsley	LOMAT	*Lomatium*	4-45	–
	fleabane	ERIGE2	*Erigeron*	4-35	–
	ballhead sandwort	ARCO5	*Arenaria congesta*	0-35	–
	Drummond's milkvetch	ASDR3	*Astragalus drummondii*	0-35	–
	milkvetch	ASTRA	*Astragalus*	0-35	–
	onion	ALLIU	*Allium*	0-22	–
	Forb, dicot, perennial	2FDP	*Forb, dicot, perennial*	0-22	–

	buckwheat	ERIOG	*Eriogonum*	4-17	–
	cinquefoil	POTEN	*Potentilla*	0-11	–
	Forb, annual	2FA	*Forb, annual*	0-6	–
Shrub/Vine					
3				82-143	
	Wyoming big sagebrush	ARTRW8	*Artemisia tridentata ssp. wyomingensis*	40-143	–
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0-143	–
	winterfat	KRLA2	*Krascheninnikovia lanata*	8-100	–
	spineless horsebrush	TECA2	*Tetradymia canescens*	0-85	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	15-76	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0-17	–
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0-15	–
	Shrub, other	2S	*Shrub, other*	0-15	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0-8	–

Table 7. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 8. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 9. Community 2.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 10. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 11. Community 4.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 12. Community 4.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Table 13. Community 5.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)

Animal community

The Droughty ecological site of the Central Rocky Mountains Valleys, LRU 01 Subset A, provides a variety of wildlife habitat for an array of species. Prior to the settlement of this area, large herds of antelope, elk, and bison roamed. Though the bison have been replaced, mostly with domesticated livestock, elk and antelope still frequently utilize this largely intact landscape for 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 Bunchgrass Community (1.1) is likely to have a minimal sage grouse presence given its low sagebrush canopy cover and forb components. Other communities on the site with sufficient sagebrush cover may harbor sage grouse populations, specifically Community 2.1 (needle and thread/sagebrush), where big sagebrush populations increase under a reduced fire regime. Additionally, as sagebrush canopy cover increases in Altered States 2.1 and 2.2, pygmy rabbits, Brewer's sparrows, and mule deer use may 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 dry site's productivity, grazing on adjacent sites with lower production must be carefully managed to ensure that utilization on this site is not excessive.Management objectives should include maintenance or improvement of the native plant community. Careful management of the timing and duration of grazing is important. Shorter grazing periods and adequate deferment during the growing season are recommended for plant maintenance, health, and recovery. According to McLean et al., early-season defoliation of bluebunch wheatgrass can result in high mortality and reduced vigor in plants. They also suggest, based on prior studies, that the opportunity for regrowth is necessary before dormancy to reduce injury bluebunch. 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 will help utilize needle and thread more efficiently. Continual non-prescribed grazing of this site will be injurious, will alter the plant composition and production over time, and will result in the transition to the Altered State. The transition to other states will depend on the duration of poorly managed grazing as well as other circumstances such as weather conditions and fire frequency. The Altered State 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 Reference State. Grazing is possible in the Invaded State. Invasive species are generally less palatable than native grasses. Forage production is typically greatly reduced in this state. Sites infested with invasive species face an increased risk of further degradation due to their aggressive nature. 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. In the Degraded Shortgrass State, grazing may be possible but 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 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 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 25 percent covered. 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. (McCalla et al., 1984)

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.

Inventory data references

Information presented was derived from the site's Range Site Description (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).

References

. (Date accessed). **Fire Effects Information System**. http://www.fs.fed.us/database/feis/.

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

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

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

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

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

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

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

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

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

Daubenmire, R. 1970. Steppe vegetation of Washington.

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

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.

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.

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.

Contributors

Grant Petersen
Kirt Walstad
Abe Clark
Barb Landgraf-Gibbons
Synergy Resource Solutions

Approval

Kirt Walstad, 2/11/2025

Rangeland health reference sheet

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

Author(s)/participant(s)	Grant Petersen, Benjamin Moore, Braden Pitcher, Kirt Walstad
Contact for lead author	grant.petersen@usda.gov
Date	03/04/2019
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** No Rills Present

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 (>15%) 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):** Bare ground is 15-25%

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

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

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.

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 ratings of 4-6 under both canopy and interspaces. Abiotic crusts or root mats may be present. A Horizon typically 4-7 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 typically strong to medium fine granular. The A horizon should be 4-7 inches thick with color, when wet, typically ranging in Value of 3 or less and Chroma of 3 or less. Local geology may affect color in which it is important to reference the Official Series Description (OSD) for characteristic range.

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 Droughty ecological site is well drained and has a high infiltration rate. An even distribution of mid stature grasses, ~65-70% of site production, cool season rhizomatous grasses 5-10% of site production along with a mix of shortgrass 5-10%, forbs 1-10%, and shrubs 1-10%.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Not present, some soils profiles may contain an abrupt transition to an Argillic horizon which can be misinterpreted as compaction however the soil structure will typically be fine to medium subangular blocky whereas a compaction layer will tend to be structureless.

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: short bunchgrass = rhizomatous grasses ? shrubs = forbs = warm season grasses > subshrubs

    Other: Annual native forbs & grasses are very rare

    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.**

14. **Average percent litter cover (%) and depth (in):** **Total litter cover ranges from 30 to 40%. Most litter is irregularly distributed on the soil surface and is not at a measurable depth.**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** **Average annual production is 1025. Low: 725 High 1275 lbs per acre. Production varies based on effective precipitation and natural variability of soil properties for this ecological site.**

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), Kentucky bluegrass (Poa pratensis) Note: this list may not be fully comprehensive as unknown populations of weeds may exist Native species with the ability to indicate degradation however species presence alone does not imply degradation: Sandberg bluegrass (Poa secunda), Big sagebrush (Artemisia tridentata), Three-tip sagebrush (Artemisia tripartita), Broom snakeweed (Gutierrezia sarothrae), Rubber rabbitbrush (Ericameria nauseosa), Yellow rabbitbrush (Chrysothamnus viscidiflorus), Rocky Mountain juniper (Juniperus scopulorum), Douglas fir (Pseudotsuga menziesii), Ponderosa pine (Pinus ponderosa)**

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.**