USDA Natural Resources Conservation Service

Ecological site R044AA036MT Droughty (Dr) LRU 44A-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): 044A–Northern Rocky Mountain Valleys

For further information regarding MLRAs refer to:
http://soils.usda.gov/survey/geography/mlra/index.html

Land Resource Unit (LRU) 44A-A:
• Moisture Phase: xeric, dry - ustic, dry
• Temperature Phase: frigid warm
• Dominant Cover: rangeland
• Representative Value (RV) Effective Precipitation: 10-14 inches
• RV Frost-Free Days: 90-120 days

Site Concept:
Site does not receive any additional water.
Soils are:
• moderately deep, deep, or very deep with < 15% stone and boulder cover.
• loamy-skeletal or clayey-skeletal to within 20” of soil surface.
• not strongly or violently effervescent within surface mineral 4”.
Slope is < 15%.
Soil surface texture is very fine sandy loam, loam, silt loam, silty clay loam, or clay loam in surface mineral 4”.

Associated sites

R044AA038MT	**Droughty Steep (Drstp) LRU 44A-A**
R044AA020MT	**Gravelly (Gr) LRU 44A-A** The Gravelly site is defined by moderately deep to very deep soils that are Sandy-skeletal within 10” of soil surface, whereas the Droughty site is Soil loamy-skeletal or clayey-skeletal with slopes below 15%.

Similar sites

R044AA032MT	**Loamy (Lo) LRU 44A-A** This site differs by being non-skeletal and therefore having higher water-holding capacity and higher production.
R044AA038MT	**Droughty Steep (Drstp) LRU 44A-A** This site differs by being on slopes >15%.
R044AA020MT	**Gravelly (Gr) LRU 44A-A** The Gravelly site is defined by moderately deep to very deep soils that are Sandy-skeletal within 10” of soil surface, whereas the Droughty site is Soil loamy-skeletal or clayey-skeletal with slopes below 15%.
R044AA136MT	**Shallow Loamy (Swlo) LRU 44A-A**

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Pseudoroegneria spicata* (2) *Hesperostipa comata*

Physiographic features

The Droughty (Dr) ecological site (R044AA036MT) is located within LRU “A” in MLRA “44A.” This ecological site occurs on nearly level to strongly sloping alluvial fans, stream terraces, hills, till plains, lake plains, or moraines. The slope ranges from 0-15%. This site occurs on all exposures; effect of aspect is not significant.

Table 2. Representative physiographic features

Landforms	(1) Alluvial fan (2) Stream terrace (3) Hill
Elevation	549–1,524 m
Slope	0–15%
Water table depth	107 cm
Aspect	Aspect is not a significant factor

Climatic features

The dissected Northern Rocky Mountain Valleys of MLRA 44A are considered to have a maritime climate. Precipitation is fairly evenly distributed throughout the year with less than about 35% of the annual precipitation occurring during the growing season in Montana. Rainfall occurs as high-intensity, convective thunderstorms in the spring and fall. Most of the precipitation in the winter is snow or rain on fully or partially frozen ground. Average precipitation for LRU-A is 12”, and the frost-free period averages 105 days.

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

Table 3. Representative climatic features

Frost-free period (average)	105 days
Freeze-free period (average)	125 days
Precipitation total (average)	305 mm

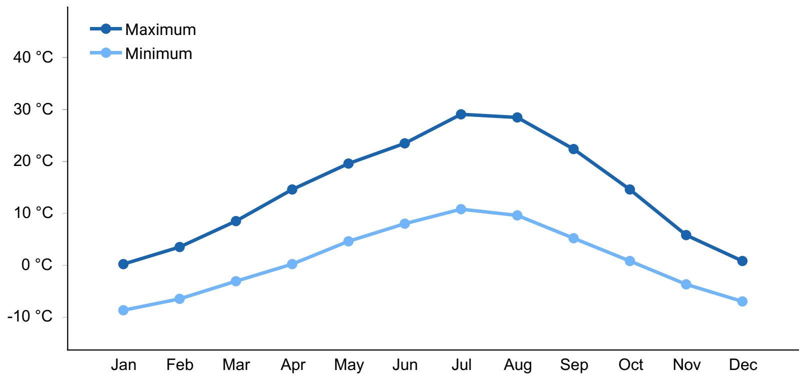

Figure 1. Monthly average minimum and maximum temperature

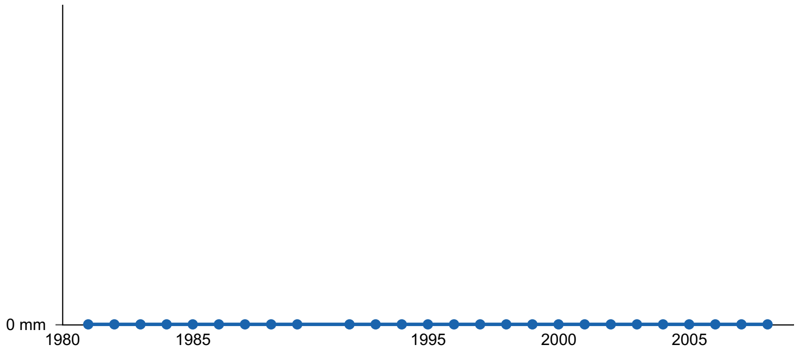

Figure 2. Annual precipitation pattern

Influencing water features

Soil features

These soils are typically very deep, well-drained soils that formed in alluvium, colluvium, and till. Soil consists of a loamy-skeletal or clayey-skeletal soil material (averages > 35% rock fragments by volume in the 10-20" layer). This skeletal material decreases the water-holding capacity of the ecological site. Skeletal soil material may or may not be present to the surface. Surface textures (< 2 mm) usually range from very fine sandy loam to silty clay loam and are typically gravelly to very gravelly.

Table 4. Representative soil features

Parent material	(1) Alluvium–sandstone and siltstone (2) Colluvium–argillite (3) Till–limestone
Surface texture	(1) Loam (2) Silt loam (3) Clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderately slow to moderately rapid
Soil depth	51 cm
Available water capacity (0-101.6cm)	0–12.45 cm
Calcium carbonate equivalent (0-101.6cm)	0–20%
Electrical conductivity (0-101.6cm)	0–1 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–12
Soil reaction (1:1 water) (0-101.6cm)	6.3–8.2

Ecological dynamics

The Droughty ecological site is characterized by the production and composition of plant species in the Reference Plant Community, which is defined by soils, precipitation, and the temperature regime influencing the site. The presumed Reference Plant Community type of this site is dominated by cool-season perennial bunchgrass species, primarily bluebunch wheatgrass (*Pseudoroegneria spicata*) with minor components of perennial forbs and low-growing shrubs. LRU-A occurs in the valleys of western Montana, on rangelands with a xeric, dry or ustic, dry soil moisture phase, a frigid, warm soil temperature phase, 10-14" of effective precipitation, and between 90 and 120 consecutive frost-free days annually. This site is characterized by medium to fine-textured soils, at least 20” deep, which are skeletal in the 10-20” zone, and slopes are less than 15%. Water-holding capacity is decreased compared to a Loamy ecological site.

The majority of precipitation comes early in the form of snow and spring rain. Summers are usually dry. The growing season is short and cool: primary growth typically occurs between May and July, and dominant plants are those that have adapted to these conditions.

In response to disastrous fires in 1910, new firefighting policies were established. Wildland fire suppression became an important driving factor in the ecology of western rangelands. Livestock grazing during the late 1800s and early 1900s often occurred at very heavy levels. Heavy grazing resulted in a severe reduction in fine fuels, which further reduced potential for natural fires. These two actions altered the natural fire interval.

Fire suppression, along with fine-fuels reduction, has interfered with the natural fire interval; many areas have not burned for over 100 years (Arno and Gruell 1986). Prior to 1900, the average natural fire return intervals were probably shorter than 35 years for this MLRA. Historic fire frequency may have ranged from 15 to 75 years. Trees and non-sprouting shrubs were restricted to small patches or widely spaced plants. Following fire on medium-textured soils, perennial bunchgrasses apparently recovered in a few years and were present to fuel subsequent fires, which suppressed woody species and kept them as a minor component of the community (Arno and Gruell 1983).

Historical records indicate, prior to the introduction of livestock (cattle and sheep) during the late 1800s, elk and bison grazed this ecological site. Evidence shows periodic use by bison in large numbers and concentrations (Lesica and Cooper 1997). Forage for livestock was noted as minimal in areas recently grazed by bison (Lesica and Cooper 1997).

Significant livestock grazing has occurred on most of this ecological site in western Montana for more than 100 years (beginning with the 1860s gold boom and subsequent settlement through 1900). Indian horse herds were present and numerous for several hundred years prior. The primary type of livestock grazed in this region has historically transitioned between sheep and cattle with early grazing (pre-1890) dominated by the cattle industry. In the 1890s Montana sheep production began to increase dramatically (by > 400%) and dominated the cattle industry for approximately four decades. By the 1930s, livestock production once again favored the cattle industry, which continues to dominate livestock grazing in the region today (Wyckoff and Hansen 2001). The Droughty ecological site is relatively accessible, and many examples were subject to heavy and/or season-long grazing until 1970 or later. Most of the deeper sites within MLRA 44A were plowed and converted to annual crops or tame pasture between 1880 and 1960.

Invasive species are an important part of the ecology of MLRA 44A. Notable invasive species include spotted knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*), sulphur cinquefoil (*Potentilla recta*), and cheatgrass (*Bromus tectorum*). Most sites in MLRA 44A are impacted by these invasives. Sites are either currently invaded or have been treated to kill invasives, which reduces the production and changes the composition of forbs and shrubs. Even where invasives are not present, the threat of invasion drives management of this site.

Anthropogenic influences on this ecological site include agriculture and urban/suburban development. Hay production has constituted the largest replacement of native vegetation with introduced cool-season annuals, perennial grass species, and legumes (e.g., alfalfa). This ecological site has also been converted to pastureland (with introduced grass or legume species) or cropland because of its relatively level topography, favorable fertility, and water-holding capacity. Other agronomic practices include crop production: some of the common crops include wheat, barley, and oats. Cropland, pastureland, and hayland are intensively managed with annual or periodic cultivation, annual harvesting, and/or frequent use of herbicides, pesticides, and commercial fertilizers to increase production. Where irrigation water is available, this site may be irrigated, which further modifies soil properties and increases production potential. Both cropland and pastureland require ongoing weed control because of residual or transported weed seed.

Cropland has seldom been abandoned in western Montana; however, those lands that are abandoned revert to “go back land.” This change occurs when converted land (previously plowed land) is abandoned or mismanaged (poor crop or haying management or improper grazing management). When a previously farmed site is left unmanaged, there is an increased risk of invasion by noxious, invasive, introduced, and/or less desirable plants such as spotted knapweed, leafy spurge, and cheatgrass.

Plowing this site may result in changes to soil structure, soil microbes (microfauna), and soil chemistry that make it difficult or impossible to return to native conditions within a practical cost range or human time scale. A return to native bunchgrass communities on the Droughty site is more likely to be successful if soil chemistry, microorganisms, and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference (or near reference) conditions. The native component of the grassland may be lost when seeding non-natives. Even when natives had been successfully reseeded, the ecological processes defining the past states of the site can significantly change.

In the short term, the site can be restored to resemble the Taller Bunchgrass State in the short term by seeding mixtures of commercially available native grasses. With proper management (prescribed grazing, weed control, or brush control) over time, this site can come close to the diversity and complexity of the Bluebunch Wheatgrass Community (1.1). Because of introduced forbs and grasses and the changes in soil properties, this site is not likely to return to near reference conditions without active restoration.

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

Rangeland Health Reference Worksheets have been posted for this site on the Montana NRCS Web site (www.mt.nrcs.usda.gov) in Section II of the eFOTG under (F) Ecological Site Descriptions (ESD).

Plant Communities and Transitional Pathways
A STM for the Droughty ecological site (44AA036MT) is 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 observations, and interpretations by experts and is likely to change as knowledge increases.

Plant communities differ across the MLRA because of 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. The species lists are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are used in this ESD. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover drives the transitions between communities and states because of the influence of shade and interception of rainfall. 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 species composition for the site. Calculating similarity index requires use of species composition by dry weight.

This STM includes only native communities and states. The converted communities are described in the Ecological Dynamics section above.

State and transition model

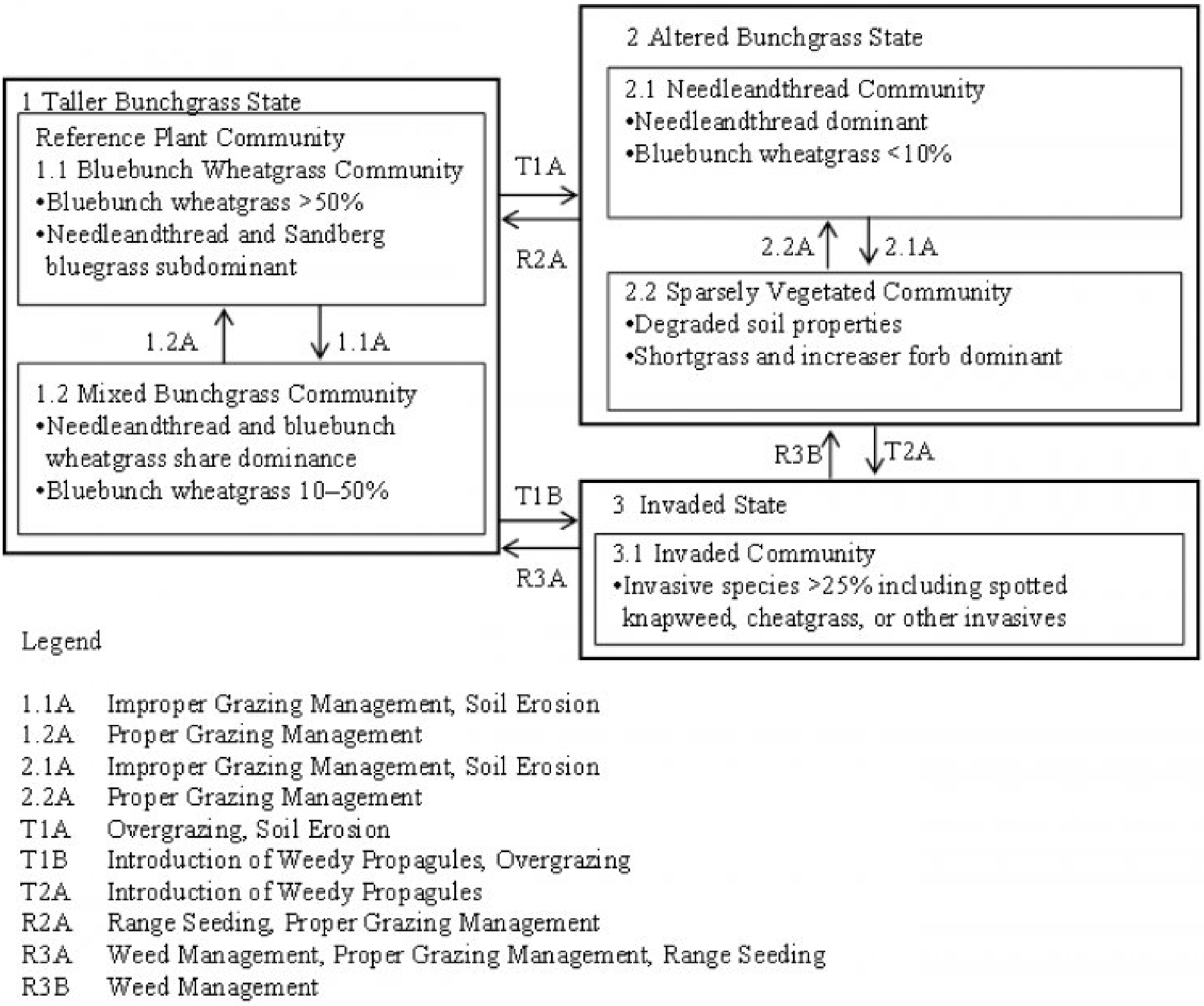

Figure 4. 44AA036MT Droughty

State 1

Taller Bunchgrass State

This state is characterized by cool-season bunchgrasses and is represented by two communities that differ mainly in the percent composition of bluebunch wheatgrass and needleandthread (*Hesperostipa comata*). Shrubs and forbs are a minor component in this state.

Community 1.1
Reference Plant Community - Bluebunch Wheatgrass Community

Figure 5. 44AA Droughty 4

Figure 6. 44AA Droughty 5

Figure 7. 44AA Droughty 1

Figure 8. 44AA Droughty 2

Figure 9. 44AA Droughty 3

The Bluebunch wheatgrass Community (1.1) is dominated by bluebunch wheatgrass, a taller cool-season bunchgrass with a minor component of forbs and low-growing shrubs. Bluebunch wheatgrass is typically the dominant species in the Bluebunch Wheatgrass Community (1.1). Needleandthread and Sandberg bluegrass (*Poa secunda*) are subdominant. Many common forb species exist on this site, including bigseed biscuitroot (*Lomatium macrocarpum*). Low-growing shrub species, including fringed sagewort (*Artemisia frigida*), are present as a minor part of the community. The Taller Bunchgrass State occurs generally on the Droughty site in areas where proper grazing management practices have been implemented over a long time period. The Bluebunch Wheatgrass Community can be maintained through the implementation of properly managed grazing that provides adequate growing-season deferment to allow establishment of taller grass propagules and/or the recovery of vigor of stressed plants. The Bluebunch Wheatgrass Community (1.1) in general is resistant to change with proper grazing management and near normal precipitation. However, bluebunch wheatgrass lacks resistance to grazing during the spring growing season. Subdominant species, such as needleandthread, tolerate higher grazing pressure, and may increase in cover under prolonged drought conditions. This increase drives the community shift to the Mixed Bunchgrass Community (1.2). The Bluebunch Wheatgrass Community is moderately resilient. The community will return to dynamic equilibrium (1.2A) following a relatively short period of stress, such as drought or short-term overgrazing, provided the return of favorable or normal growing conditions occurs along with implementation of proper grazing management. This equilibrium will occur if canopy cover did not fall below 50%, and bluebunch wheatgrass did not fall below 10% of species composition. Bluebunch wheatgrass lacks resistance to grazing during the critical growing period during spring. Bluebunch wheatgrass may decline in vigor and production if grazed in the spring more than one year in three (McLean and Wikeem 1985, Wilson et al. 1960). Periodic fire increases the resilience of the Bluebunch Wheatgrass Community (1.1) by reducing competition and canopy cover of less fire-tolerant species. Fire also removes decadent herbaceous material, particularly from taller bunchgrasses, which promotes increased vigor and seedling establishment. Timing and intensity of a fire are critical components that can have varying positive or negative effects on this plant community when using fire. Fire does increase risk of invasion from invasive species, most notably cheatgrass. At least two growing seasons of rest are recommended to allow plants to recover after fire. Increaser species on this site are generally endemic species released by disturbance. These subdominant species of grasses, forbs, and shrubs are more tolerant to grazing pressure than bluebunch wheatgrass. Improper grazing management can reduce vigor of bluebunch wheatgrass, which can lead to reduced plant size or plant death. Species with high grazing tolerance will increase in production as they use resources made available by the decrease in bluebunch wheatgrass. Improper grazing management can also lead to degraded soil properties through compaction, erosion, decrease in organic matter, and increase in exposure because of reduction in litter cover. Needleandthread grass is not only more tolerant to higher grazing pressure, but can also grow on less fertile soils than bluebunch wheatgrass (USDA/NRCS 2007). Under improper grazing management, the Bluebunch Wheatgrass Community (1.1) shifts to the Mixed Bunchgrass Community (1.2). If overgrazing continues, invasive weedy grass and forb species can move into the plant community and the site can transition to the Invaded State (3). While the Bluebunch Wheatgrass Community (1.1) is resilient to degradation under proper management, the community remains at risk of invasion by aggressive non-native species because of the ability of spotted knapweed, leafy spurge, and cheatgrass to invade healthy rangelands and the widespread presence of propagules. Healthy plant communities are most resilient to invasives although many examples exist of well-managed areas that have been invaded by spotted knapweed. Due to the ability of spotted knapweed and other aggressive species to invade any community, all communities, including the Reference Community (1.1) are “at risk communities” to cross the threshold to the Invaded State (3). Invasives may impact this plant community even if the site does not yet have a critical population of invasives. Almost all reference sites had at least trace amounts of spotted knapweed and/or cheatgrass. It is believed that most sites with only trace amounts have been chemically treated for invasives at some point. These treatments would have impacted other broad-leafed species (forbs and shrubs). It is likely that this site had more potential for forb and shrub production than found on current reference sites. Rock cover on the soil surface is minimal and does affect productivity of this site. Plant basal cover is expected to be about 15-25% with 10-15% bare ground. The soils of this site have high soil stability values. There should be no signs of current erosion occurring on the site. The following production figures do not represent the lowest or highest possible production for the reference community (1.1). For example, the high figure is not the most production that can occur in a wet year in the most mesic portion of the LRU. These values represent the range of variability for each species across the extent of the ecological site. Usually, values in the low production column represent production at the dry end of the LRU and those in the high production column represent production at the wet end of the LRU. Even the most stable communities exist within a range of dynamic equilibrium of species composition. Therefore, the following table shows an example of species composition; the example is not the only mix of species possible in the Bluebunch Wheatgrass Community (1.1).

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	667	953	1239
Shrub/Vine	78	112	146
Forb	39	56	73
Total	**784**	**1121**	**1458**

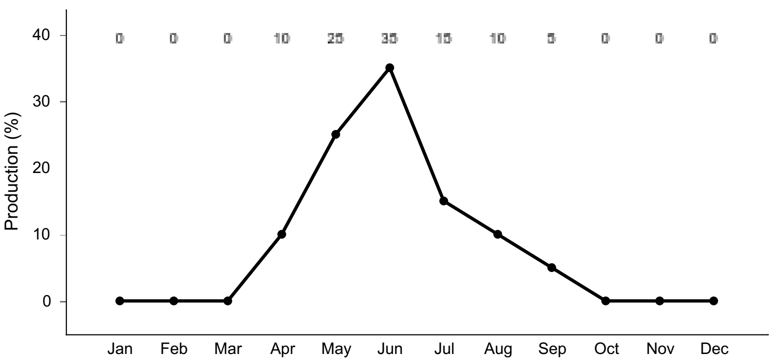

Figure 11. Plant community growth curve (percent production by month). MT0441, 44A - Uplands. Includes all upland sites in 44A.

Community 1.2
Mixed Bunchgrass Community

Needleandthread tolerates grazing pressure better than bluebunch wheatgrass and is better adapted to less fertile soil conditions than bluebunch wheatgrass. Needleandthread increases in species composition when more palatable and less grazing tolerant plants decrease because of improper grazing management. Needleandthread and bluebunch wheatgrass share dominance in the Mixed Bunchgrass Community (1.2). Other grass species that are more tolerant to grazing and are likely to increase compared to the Reference Plant Community include Sandberg bluegrass, prairie junegrass (*Koeleria macrantha*), and western/thickspike wheatgrass (*Pascopyrum smithii*, *Elymus trachycaulus*). Some increaser forbs species include western yarrow (*Achillea millefolium*), hoods phlox (*Phlox hoodii*), scarlet globemallow (*Sphaeralcea coccinea*), hairy goldenaster (*Heterotheca villosa*), and pussytoes (Antennaria spp.). Fringed sagewort is a shrub that also increases under prolonged drought or heavy grazing. Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to erosion. Litter and mulch will move off-site as plant cover declines. As long as the canopy cover remains > 50% and production of bluebunch wheatgrass is > 10% of total biomass production, the site can return to the Bluebunch Wheatgrass Community (Pathway 2.1A) under proper grazing management and favorable growing conditions. Needleandthread will continue to increase until it makes up 80% or more of species composition. Once bluebunch wheatgrass has been reduced to < 10% and canopy cover has decreased to below 50%, it may be difficult for the site to recover to the Reference Plant Community (1.1). The risk of soil erosion increases when canopy cover decreases below 50%. As soil properties degrade, there will be loss of organic matter, reduced litter, compaction, and reduced soil fertility. Degraded soil properties increase the difficulty of reestablishing bluebunch wheatgrass and returning to the Reference Plant Community (1.1). The Mixed Bunchgrass Community (1.2) is the At-Risk Plant Community for this ecological site. When overgrazing continues, increaser species such as needleandthread and native forb species become more dominant and this triggers the change to the Altered Bunchgrass State (2) or the Invaded State (3). Until the Mixed Bunchgrass Community (1.2) crosses the threshold into the Needleandthread Community (2.1) or the Invaded Community (3.1), this community can be managed toward the Bluebunch Wheatgrass Community (1.1) using prescribed grazing and strategic weed control. It may take several years to achieve this recovery, depending on growing conditions, vigor of remnant bluebunch wheatgrass plants, and aggressiveness of weed treatments.

Pathway 1.1A
Community 1.1 to 1.2

Bluebunch wheatgrass loses vigor when overgrazed. When vigor declines enough for plants to die or become smaller, species with higher grazing tolerance (most often needleandthread) increase in vigor and production as they use the resources previously used by bluebunch wheatgrass. Decrease of species composition by weight of bluebunch wheatgrass to < 50% indicates that the plant community has shifted to the Mixed Bunchgrass Community (1.2). The driver for this community pathway is improper grazing management. This shift is triggered by the loss of vigor of bluebunch wheatgrass.

Pathway 1.2A
Community 1.2 to 1.1

The Mixed Bunchgrass Community (1.2) will return to the Bluebunch Wheatgrass Community (1.1) with proper grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. The driver for this community pathway is the increase in vigor of bluebunch wheatgrass to the point that it represents more than 50% of species composition. The trigger for this shift is the change in grazing management that favors bluebunch wheatgrass.

State 2
Altered Bunchgrass State

This state is characterized by having < 10% bluebunch wheatgrass and < 50% canopy cover. State 2 is represented by two communities that differ in the percent composition of needleandthread, production, and soil degradation. Production in this state is considerably lower than in the Taller Bunchgrass State (1). Some native plants tend to increase under prolonged drought and/or heavy grazing practices. A few of these species may include needleandthread, Sandberg bluegrass, western yarrow, scarlet globemallow, hairy goldenaster, and fringed sagewort.

Community 2.1
Needleandthread Community

Long-term grazing mismanagement with continuous growing-season pressure will reduce total productivity of the site and lead to an increase of bare ground. Once plant cover is reduced, the site is more susceptible to erosion and degradation of soil properties. Soil erosion or reduced soil fertility will create reduced plant production. This soil erosion or loss of soil fertility indicates the transition to the Altered Bunchgrass State (2) because it creates a threshold that requires input of energy to return to the Taller Bunchgrass State (1). The transition to the Needleandthread Community (2.1) may be exacerbated by extended drought conditions. Needleandthread dominates the Needleandthread Community (2.1). Bluebunch wheatgrass makes up < 10% of species composition by dry weight and the remaining bluebunch wheatgrass plants tend to be scattered and low in vigor. Increaser and invader species will become more common and will create more competition for bluebunch wheatgrass in the community. This competition makes it difficult for bluebunch wheatgrass to increase in a shorter period with simply a change in grazing management alone. Therefore, an input of energy will be required for the community to return to the Taller Bunchgrass State (1). Proper grazing management over a long time period is a successful strategy to increase cover and production of bluebunch wheatgrass. Canopy cover decreases compared to the Mixed Bunchgrass Community (1.2) to< 50%. Wind and water erosion may be eroding soil from the plant interspaces. Soil fertility is reduced, soil compaction is increased, and resistance to soil surface erosion has declined compared to the Taller Bunchgrass State (1). This community has crossed a threshold compared to the Mixed Bunchgrass Community (1.2) because of the soil erosion, loss of soil fertility, or degradation of soil properties, which causes a critical shift in the ecology of the site. The affects of soil erosion can alter the hydrology, soil chemistry, soil microorganisms, and soil physics to the point where intensive restoration is required to restore the site to another state or community. Simply changing grazing management cannot create sufficient change to restore the site within a reasonable time period. Restoration will require a considerable input of energy to move the site back to the Taller Bunchgrass State (1). This state has lost soil or vegetation attributes to the point that recovery to the Taller Bunchgrass State (1) will require reclamation efforts, i.e., soil rebuilding, intensive mechanical treatments, and/or reseeding. The transition to this state could occur because of overgrazing (often because of failure to adjust stocking rates in response to declining forage production because of increased dominance of unpalatable invasive species), long-term lack of fire, warming climate, or extensive drought. If heavy grazing continues, plant cover, litter, and mulch will further decrease and bare ground will further increase exposing the soil to accelerated erosion. Litter and mulch will move off-site as plant cover declines. The Needleandthread Community will then shift to a Sparsely Vegetated Community (2.2). Introduction or expansion of invasive species will further drive the plant community to the Invaded State (3).

Community 2.2
Sparsely Vegetated Community

Very sparse plant cover and soil surface erosion characterize this community. Grass and forb cover may be very sparse or clumped (canopy cover < 25%). Weeds, annual species, or shortgrass species dominate the plant community. Mid-stature perennial bunchgrass species (e.g., needleandthread) may exist, but only in patches. In this community phase, there may be a significant amount of bare ground, and large gaps may occur between plants. Potential exists for soils to erode to the point that irreversible damage may occur. If further soil erosion occurs, there will be a critical negative shift in the ecological processes of this site. Soil erosion combined with lack of organic matter deposition because of sparse vegetation creates changes to the hydrology, soil chemistry, soil microorganisms, and soil physics to the point where intensive restoration is required to restore the site to another state or community. Simply changing management (i.e., improving grazing management) cannot create sufficient change to restore the site within a reasonable time period. This plant community may be in a terminal state that will not return to the reference state because of degraded soil properties and loss of higher successional native plant species.

Pathway 2.1A
Community 2.1 to 2.2

With continued overgrazing, bunchgrasses and perennial forbs can decrease in the Needleandthread Community (2.1). Loss of larger bunchgrasses and rhizomatous grasses will increase bare soil and allow increased soil erosion. This shift is frequently accompanied by decreased soil fertility and diminished soil properties. Decreased plant vigor drives this shift. This shift is triggered by continued overgrazing or extended drought in a Needleandthread Community (2.1) with poor vigor. Lack of mid-stature bunchgrasses and low production indicates a community shift to the Sparsely Vegetated Community (2.2).

Pathway 2.2A
Community 2.2 to 2.1

If a Sparsely Vegetated Community (2.2) is properly managed for several years and growing conditions are favorable, annual production of perennial bunchgrasses and rhizomatous grasses may increase over time, and the site may shift back to the Needleandthread Community (2.1). The driver for this shift is increased vigor of bunchgrasses and rhizomatous grasses. The trigger is improved grazing management and growing conditions over a long time period.

State 3
Invaded State

The single community described below characterizes this state.

Community 3.1
Invaded Community

The Invaded State (3) is characterized by > 25% of invasive species with spotted knapweed, leafy spurge, sulphur cinquefoil, and/or cheatgrass are the dominant invasive species in MLRA 44A. Introduced exotic plant species have been identified as one of the greatest threats to the integrity and productivity of native rangeland ecosystems and conservation of indigenous biodiversity (DiTomaso 2000; Mack et al. 2000). In addition to environmental consequences, damages caused and costs incurred to control invasive plants are several billion dollars each year in the United States (Pimentel et al. 2000). Invasives are the driving factor throughout western Montana, and they are a focal part of the ecology of MLRA 44A. Their ability to take over and dominate a site has become a big concern. Improper grazing management has contributed to the spread of these species. The potential for altered ecosystem structure and function is high in the Invaded State (3) and can occur in many ways. The increase in invasive species, especially noxious weeds, can lead to a reduction of the native bunchgrasses and an increase in the proportion of bare ground, which often results in reduced infiltration rates and increased surface runoff and erosion. Invasion by cheatgrass reduces above and below ground biomass (Ogle et al. 2003), increases plant litter, changes plant community canopy architecture (Belnap and Phillips 2001), reduces soil biota richness and abundance, reduces plant community richness (Belnap et al. 2005), increases wildfire frequency (Whisenant 1990), and potentially facilitates invasion by other noxious or invasive plants. Dense populations of invasive species can cause soil loss to increase because of lack of surface cover (Lacey et al. 1989). Early in the invasion process, there is a lag phase where invasive plant populations remain small and localized before expanding exponentially (Hobbs and Humphries 1995). Based on research conducted in noxious weed-invaded plant communities in Montana, it is reasonable to estimate that 25% dry-weight composition of invasive plant species is the point in the invasion process where spread and abundance is increasing exponentially and where a plant community has crossed a threshold (Masters and Sheley 2001). For aggressive invasive species (i.e., spotted knapweed), this threshold could be < 10%. 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 (3). Once invasive species such as spotted knapweed, cheatgrass, and leafy spurge become established, they are very difficult to eradicate. Therefore, considerable effort should be placed in preventing plant communities from crossing a threshold to the Invaded State (3) 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 weed management strategy that incorporates one or several of these options along with education and prevention efforts (DiTomaso 2000). Production in the invaded community may vary greatly. A site dominated by spotted knapweed, where soil fertility and chemistry remain near potential, may have production near that of the reference community. A site with degraded soils and an infestation of cheatgrass may produce only 10-20% of the reference community. Invasive plant species have effective reproductive strategies, long seed viability in the soil seed bank, and/or allelopathic properties (Williamson and Fitter 1996). Spotted knapweed has allelopathic properties whereby its roots exude catechin, which may limit the growth and establishment of other plant species (Callaway and Vivanco 2007; Bais et al. 2002), thus promoting its own success. An in-vitro experiment showed that other weeds like Dalmatian toadflax (*Linaria dalmatica*), kochia (Kochia scoparia), diffuse knapweed (*Centaurea diffusa*), and crops such as wheat (*Triticum aestivum*), showed mortality on the fourteenth day after addition of root exudates from spotted knapweed (Bais et al. 2002). This allelopathic property creates highly resilient communities. Cheatgrass has the ability to establish rapidly and attain community dominance following disturbances such as wildfire (Young and Evans 1978) or other disturbances creating bare soil.

Cheatgrass is a successful invader because it has the ability to respond rapidly to increases in resource availability (Norton et al. 2004; Lowe et al. 2003) as well as to compete for water (Pellant 1996). Cheatgrass was introduced into the United States in packing materials, ship ballast, and likely as a contaminant of crop seed. Cheatgrass was first found in the United States near Denver, Colorado, in the late 1800s. In the late 1800s and early 1900s, cheatgrass spread explosively in the ready-made seedbeds prepared by the trampling livestock hooves of overstocked rangelands. Cheatgrass has developed into a severe weed in several agricultural systems throughout North America, particularly western pastureland, rangeland, and winter wheat fields (NRCS 2009). Today, cheatgrass is found in most of the western states, having reached its range of current distribution by 1930. In fact, a survey of 11 western states showed that cheatgrass was present on at least 60 million acres (Pellant 1996). After arriving in 1893 on the San Juan Islands in Washington, spotted knapweed had established in over 24 counties in three northwestern states by 1924, with several large infestations near Missoula, Montana (Sheley et al. 2005). By 1975, spotted knapweed had spread into most of the western counties of Montana, and today it is found in every county in Montana. Leafy spurge, a native to Eurasia, was sighted in Park County, Montana as early as 1925 and has since been found in every county in Montana. Overgrazing by livestock has contributed to the spread of leafy spurge (Sheley et al. 2005).

Transition T1A
State 1 to 2

The Taller Bunchgrass State (1) transitions to the Altered Bunchgrass State (2) if plant canopy cover declines to < 50% and bluebunch wheatgrass decreases to below 10% by dry weight. The trigger for this transition is the loss of taller bunchgrasses, which creates open spots of bare soil. Soil erosion is accompanied by decreased soil fertility driving transitions to the Altered Bunchgrass State. There are several other key factors signaling the approach of transition T1A: increases in soil physical crusting, decreases in cover of cryptogamic crusts, decreases in soil surface aggregate stability and/or evidence of erosion including water flow patterns, development of plant pedestals, and litter movement. The driver for this transition is improper grazing management and/or long-term drought leading to a decrease in bluebunch wheatgrass composition to < 10%.

Transition T1B
State 1 to 3

Regardless of grazing management, without some form of weed management (chemical, mechanical, or biological control), the Taller Bunchgrass State (1) can transition to the Invaded State (3) if aggressive invasive species, such as spotted knapweed and cheatgrass are introduced, even if the herbaceous component of the reference community is thriving. Healthy plant communities are most resilient to invasives. Long-term stress conditions for native species (e.g., overgrazing, drought, and fire) accelerate the process. If populations of invasive species reach critical levels, the site transitions to the Invaded State. The driver for this transition is the presence of aggressive invasive species.

Restoration pathway R2A
State 2 to 1

The Altered Bunchgrass State (2) has lost soil or vegetation attributes to the point that recovery to the Taller Bunchgrass State (1) will require reclamation efforts, such as soil rebuilding, intensive mechanical treatments, and/or revegetation. The drivers for this restoration pathway are reclamation efforts and proper grazing management. The trigger is restoration efforts.

Transition T2A
State 2 to 3

Invasive species can occupy the Altered Bunchgrass State (2) and drive it to the Invaded State (3). The Altered Bunchgrass State is at risk of this transition occurring if invasive propagules are present. The driver for this transition is the presence of critical population levels (> 25%) of invasive species. The trigger is the presence of propagules of invasive species.

Restoration pathway R3A
State 3 to 1

Restoration of the Invaded State (3) to the Taller Bunchgrass State (1) requires substantial energy input. The drivers for this restoration pathway are removal of invasive species, restoration of native bunchgrass species, ongoing management of invasives, and proper grazing management. Without maintenance, invasive species are likely to return (probably rapidly) because of the presence of propagules in the soil and increases in soil disturbance. The drivers for this reclamation pathway are treatments to reduce or remove invasive/noxious species in combination with favorable growing conditions. The trigger is invasive species control.

Restoration pathway R3B
State 3 to 2

If invasive species are removed without sufficient remnant populations of reference community species (particularly bluebunch wheatgrass), the Invaded State (3) is likely to return to the Altered Bunchgrass State (2) instead of the Taller Bunchgrass State (1). The driver for the reclamation pathway is weed management without reseeding. The trigger is invasive species control.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Cool Season Bunchgrass**			667–1239	
	bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	549–1020	–
	needle and thread	HECO26	*Hesperostipa comata*	235–437	–
	green needlegrass	NAVI4	*Nassella viridula*	39–73	–
2	**Shortgrasses/Rhizomatous Grasses/Grasslikes**			78–146	
	Grass, perennial	2GP	*Grass, perennial*	39–73	–
	purple threeawn	ARPU9	*Aristida purpurea*	39–73	–
	sedge	CAREX	*Carex*	39–73	–
	thickspike wheatgrass	ELLA3	*Elymus lanceolatus*	39–73	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	39–73	–
	western wheatgrass	PASM	*Pascopyrum smithii*	39–73	–
	Sandberg bluegrass	POSE	*Poa secunda*	39–73	–
Forb					
3				39–73	
	Forb, annual	2FA	*Forb, annual*	22–39	–
	Forb, perennial	2FP	*Forb, perennial*	22–39	–
	common yarrow	ACMI2	*Achillea millefolium*	22–39	–
	rosy pussytoes	ANRO2	*Antennaria rosea*	22–39	–
	twin arnica	ARSO2	*Arnica sororia*	22–39	–
	aster	ASTER	*Aster*	22–39	–
	milkvetch	ASTRA	*Astragalus*	22–39	–
	field chickweed	CEAR4	*Cerastium arvense*	22–39	–
	fleabane	ERIGE2	*Erigeron*	22–39	–
	bigseed biscuitroot	LOMA3	*Lomatium macrocarpum*	22–39	–
	thinleaved owl's-clover	ORTE2	*Orthocarpus tenuifolius*	22–39	–
	phlox	PHLOX	*Phlox*	22–39	–
	woolly plantain	PLPA2	*Plantago patagonica*	22–39	–
Shrub/Vine					
4	**Shrubs**			78–146	
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	39–73	–
	prairie sagewort	ARFR4	*Artemisia frigida*	39–73	–
	yellow rabbitbrush	CHVI8	*Chrysothamnus viscidiflorus*	39–73	–
	rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	39–73	–
	Woods' rose	ROWO	*Rosa woodsii*	39–73	–

Animal community

Livestock grazing is suitable on this site due to the potential to produce high quality forage. This site may be preferred for grazing by livestock, and animals may congregate in these areas. Management objectives should include maintenance or improvement of rangeland health attributes of this ecological site. Careful management of timing, intensity and duration of grazing to minimize grazing re-growth and providing adequate rest is important. Shorter grazing periods and changing season of use during the growing season are recommended for plant maintenance, health and recovery.

Continuous grazing with improper stocking rates throughout the growing season in pastures year after year will be detrimental, will alter the plant composition and production over time, and will result in a transition to the Mixed Bunchgrass Community (1.2) or potentially hasten a change to the Invaded State (3.1). Transition to other states will depend on how well the site is managed over time with grazing animals as well as other circumstances such as weather conditions over a period of time.

The transition to the Mixed Bunchgrass Community (1.2) can be the result of long-term, continuous grazing and/or repeated critical growing season grazing (early season grazing during stem elongation). This transition can also occur due to a combination of overgrazing and drought. Repeated grazing during stem elongation (generally mid-April through mid-June), can have detrimental affects, especially on the taller key bunchgrass species. Repeated spring grazing and/or repeated and prolonged summer grazing depletes stored carbohydrates, resulting in poor vigor of key forage plants over time and eventual death of these cool-season grasses – this can lead to an increase in less desirable native species and/or noxious weeds.

The Mixed Bunchgrass Community (1.2) can occur across the entire ecological site or can occur in a mosaic with higher and/or lower states. This is most notable in areas that attract additional grazing, such as water sources or salting locations.

The Mixed Bunchgrass Community (1.2) is subject to further degradation to the Altered Bunchgrass State (2) or Invaded State (3). Management should focus on grazing management strategies that will prevent further degradation. Forage quantity and/or quality may be substantially reduced compared to the Reference Plant Community.

In the Altered Bunchgrass State, forage production is substantially reduced compared to the Taller Bunchgrass State. Grazing is possible in the Invaded State, but invasive species are generally much less palatable than native grasses and forage production is greatly reduced in this state. Grazing should be carefully managed to avoid soil loss and degradation of soil properties as well as to ensure adequate livestock health.

Prescriptive grazing should be included in a conservation plan to maintain vigor of key native plant species while targeting the invasive species problem. In some instances, carefully targeted grazing (sometimes in combination with other treatments) can reduce or eliminate populations of invasive species.

Distance to drinking water and slope can reduce grazing capacity within a management unit. Adjustments should only be made for the area that is considered necessary for reduction of animal numbers. For example 30% of a management unit may have 25% slopes and distances of > 1 mile from water; therefore the adjustment is only calculated for 30% of the unit (50% reduction on 30% of management unit). The table below is a general guide for ranches in Montana (Ricketts et al. 2004). Fencing, slope length, management, access, terrain and breeds are all factors that can increase or decrease the percent of grazable acres within a management unit. Adjustments should be made that incorporate pasture conditions when calculating stocking rates.

Hydrological functions

The water cycle functions best in the Taller 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 total ground cover of around 85%. High ground cover reduces raindrop impact on the soil surface, which keeps erosion and sedimentation transport low. Water leaving the site will have minimal sediment load, which allows for high water quality in associated streams. High rates of infiltration will allow water to move below the rooting zone during periods of heavy rainfall. The Bluebunch Wheatgrass Community (1.1) should have no rills or gullies present and drainageways should be vegetated and stable.

Improper grazing management results in a community shift to the Mixed Bunchgrass Community (1.2). This plant community has slightly reduced canopy cover, but bare ground will be less than 10%. Therefore, the water 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 Altered Bunchgrass State (2) and the Invaded State (3), canopy and ground cover are greatly reduced compared to the Taller Bunchgrass State (1), which impairs the water cycle. Infiltration will decrease and runoff will increase because of reduced ground cover, rainfall splash, soil capping, reduced organic matter, and poor structure. Sparse ground cover and decreased infiltration can combine to increase frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor, and sedimentation increases.

Recreational uses

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

Wood products

None

Other products

None

Other information

None

Inventory data references

Information presented was derived from the site's Range Site Description (Silty Droughty 10-14" P.Z., Northern Rocky Mountain Valley Bottoms, West of Continental Divide), NRCS clipping data, literature, field observations (based on three sampled sites and observations from numerous others), and personal contacts with range-trained personnel (i.e., used professional opinion of agency specialists, observations of land managers, and outside scientists).

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Approval

Kirt Walstad, 2/05/2022

Rangeland health reference sheet

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

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Contact for lead author	NRCS Missoula Area Office
Date	03/01/2010
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are unlikely to occur in the Taller Bunchgrass State.

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2. **Presence of water flow patterns:** Water flow patterns are generally not evident in the reference state. Following occasional (5 – 30 % probability), heavy thunderstorms and winter thaw events, short, sinuous, discontinuous flow patterns may be apparent, but rare, on slopes ranging from 4 – 15%. Water flow patterns should not be evident on slopes lower than 4%.

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3. **Number and height of erosional pedestals or terracettes:** None to very slight. Rarely pedestals up to 0.5 inches may be encountered.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground should be between 10-15% - bare areas tend to be inconspicuous and not connected.

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5. **Number of gullies and erosion associated with gullies:** Gullies should not occur in the Taller Bunchgrass State. If there is evidence of past erosion that has created gullies, these areas should be stabilized and have no active erosion.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Appearance or evidence of these erosional features or the landscape would not be present on this site.

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7. **Amount of litter movement (describe size and distance expected to travel):** Litter will be evident across this site representing organic debris from the vegetation of the functional/structural groups and will not move. A severe convection storm or a significant thaw event could cause litter to move short distances, especially on slopes greater than 6%.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Resistance to erosion will be high with soil stability values of 5 or 6; areas of bare soil on this site may have values between 3 and 5 if not under plant canopy.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Structure is granular at the soil surface. Organic matter is about 1.5%. The surface horizon is 3 to 6 inches thick.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The reference plant community (1.1) is dominated by bluebunch wheatgrass which will maximize infiltration and minimize runoff throughout the site. With the increase of needleandthread in Plant community (1.2) infiltration may slightly decrease and runoff may slightly increase but overall this plant community will have only minor affects on infiltration and runoff.

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** A compaction layer would not be expected on this ecological site. A platy soil surface structure would indicate a departure from the reference state.

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

    Dominant: Plant community 1.1 - Taller cool season bunchgrasses (bluebunch wheatgrass) >> mid-stature cool season bunchgrasses (needleandthread) > cool season rhizomatous grasses (western wheatgrass), shortgrasses (prairie junegrass) and grasslikes (sedges) = shrubs > perennial forbs. Plant community 1.2 – bluebunch wheatgrass and needleandthread share dominance – the other functional/structural groups will remain the same in descending order.

    Sub-dominant:

    Other:

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Plant mortality for all functional groups will be low, but there will be some natural mortality of functional groups over time. Prolonged droughts and/or excessive rest may show increases in mortality and decadence for all plant groups.

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14. **Average percent litter cover (%) and depth (in):** Note: the majority of the litter in the plant community in the Taller Bunchgrass State will be non-persistent.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 700 #/acre – 1300 #/acre for the reference community (1.1) with a RV of 1000 #/acre.

Production varies based on effective precipitation and natural variability of soil properties for this ecological site.

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

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17. **Perennial plant reproductive capability:** All native plants are capable of reproducing sexually and/or vegetatively.
