USDA Natural Resources Conservation Service

Ecological site EX043B15I954
Montane Very Deep Meadow 20-24" PZ Cryic Northern Rocky Mountain Front

Last updated: 5/06/2024
Accessed: 05/11/2025

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): 043B–Central Rocky Mountains

This ecological site currently resides in the Major Land Resource Area (MLRA) 43B Central Rocky Mountains. The area of MLRA 43B is expansive and is further divided into Land Resource Units (LRU). A detailed description of MLRA 43B can be found at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_053624
This ecological site resides within the eastern portion of Glacier National Park which resides in MLRA 43B and LRU A – Northern Rocky Mountain Front.

LRU notes

This ecological site resides within the eastern portion of Glacier National Park which resides in MLRA 43B and LRU A – Northern Rocky Mountain Front.
The landscape is mountains and the landforms include scarp slopes, dip slopes, mountain slopes, drainageways, bog, cirque, U-shaped valley and associated moraine and outwash features. Elevations range 1,000-3,175 meters (3,300-10,500 feet) (mean elevation is 1,900 m. or 6,200 ft.). The climate is cold and wet with mean annual precipitation of 1,050 mm (41 in.) and mean annual air temperature of 3 degrees C. (37 degrees F.) with a soil temperature regime of cryic and soil moisture regime of udic or ustic. The geology of the area is dominated by Appenkunny and Grinnell argillite, Kootenai formation, Tertiary sedimentary rocks, Missoula group quartzite, glacial drift alluvium, Siyeh limestone and undifferentiated rock. The soils are dominantly moderately deep to very deep that formed from a variety of sedimentary rock parent materials on moderately steep to very steep mountain slopes. Soils fall into three soil orders: Inceptisols, Mollisols, and Alfisols. Most soils are loamy-skeletal and many, especially in the eastern part, contain significant amounts of calcium carbonate influencing both physical and chemical soil characteristics (horizons of calcium carbonate accumulation and corresponding alkaline pH values). Rock outcrop, rubble land, and surface rock fragments are common. There are few lakes but has numerous major drainages including Dearborn, Sun, Teton, Birch, Badger, Two Medicine, St. Maries, South and Middle Fork Flathead headwaters, Blackfoot headwaters. This is a snow dominated system. Wind is a major force shaping climatic patterns and vegetation structure. This area includes forested areas dominated by either Douglas fir, subalpine fir or white bark pine, and range areas dominated by rough fescue, Richardson’s needlegrass and bluebunch wheatgrass and assorted forbs.
This is related to the EPA land classification framework of: Level 3- 41 Canadian Rockies. Specifically, it includes Level 4-41a Northern Front.
This area is related predominantly to the USFS Provinces M333Cf Northern Rocky Mountain Front.

Classification relationships

NPS Plant Community Name:
Festuca campestris-Festuca idahoensis-Geranium viscosissimum Herbaceous Vegetation (CEGL005870)
Physiognomic Class Herbaceous Vegetation (V)

Physiognomic Subclass Perennial graminoid vegetation (V.A.)
Physiognomic Group Temperate or subpolar grassland (V.A.5.)
Physiognomic Subgroup Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
Formation Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d.)
Alliance *Festuca idahoensis* Herbaceous Alliance (A.1251)
Alliance (English name) Idaho Fescue Herbaceous Alliance
Association *Festuca campestris - Festuca idahoensis - Geranium viscosissimum* Herbaceous Vegetation
Association (English name) Prairie Fescue - Idaho Fescue - Sticky Geranium Herbaceous Vegetation
ECOLOGICAL SYSTEM(S): Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland (CES306.040)

Festuca capestris-(*Festuca idahoensis*)-*Achnatherum richardsonii* Herbaceous Vegetation (CEGL005869)
Physiognomic Class Herbaceous Vegetation (V)
Physiognomic Subclass Perennial graminoid vegetation (V.A.)
Physiognomic Group Temperate or subpolar grassland (V.A.5.)
Physiognomic Subgroup Natural/Semi-natural temperate or subpolar grassland (V.A.5.N.)
Formation Medium-tall bunch temperate or subpolar grassland (V.A.5.N.d.)
Alliance *Festuca idahoensis* Herbaceous Alliance (A.1251)
Alliance (English name) Idaho Fescue Herbaceous Alliance
Association *Festuca campestris* - (*Festuca idahoensis*) - *Achnatherum richardsonii* Herbaceous Vegetation
Association (English name) Prairie Fescue - (Idaho Fescue) - Richardson's Needlegrass Herbaceous Vegetation
ECOLOGICAL SYSTEM(S): Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland (CES306.040)

Ecological site concept

Ecological Site Concept
This 43B Montane Very Deep Meadow ecological site is found in the montane zone, with an elevation range of 1,400-2,000 meters (4,600-6,550 feet), on backslope positions with moderate slopes of 4-15 percent and southwesterly aspects on marginal ground moraines and complex landslides on lateral moraines. Infrequently, this site is found on alluvial fans, hogbacks, knobs, ledges and knolls. These are large patch sized meadows. It is dominated by rough fescue (Festuca campetris) with associated montane grasses and forbs. Idaho fescue (*Festuca idahoensis*) and shrubby cinquefoil are common, but occur in much lower canopy cover. Other associated grasses occurring infrequently but in moderate cover include: rough bentgrass (*Agrostis scabra*), Richardsons needlegrass (*Achnatherum richardsonii*), alpine timothy (*Phleum alpinum*), alpine bluegrass (*Poa alpina*) and blue wildrye (*Elymus glaucus*). Associated montane forbs include: yarrow (Achillea millefolia), bluebell bellflower (campanula rotundifolia), nineleaf biscuitroot (*Lomatium triternatum*), lupine species and northern bedstraw (*Galium boreale*). Montane shrub species that can occur although in very low cover including: white spirea (Spirea betulifolia), thimbleberry (*Rubus parviflorus*), serviceberry (Amalanchier alnifolia), creeping juniper (*Juniperus horizontalis*), kinnikinnick (*Arctostaphylos uva-ursi*), Woods rose (*Rosa woodsii*) and sulphur-flower buckwheat (*Eriogonum umbellatum*). The soils of this ecological site are predominantly very deep and well drained. Surface textures are typically gravelly loam and subsurface layers fall into the fine-loamy particle-size family. These soils are classified in the Mollisols soil order having a thick dark surface with significant enrichment of organic matter and high base saturation. More specifically, these soils are in the Pachic Argicryolls taxonomic subgroup, indicating that the surface layer of dark organic matter-rich mineral soil extends to a depth greater than 40 centimeters and there is an accumulation of clay in the subsoil horizons. The parent material is predominantly till from metamorphic and sedimentary rock. Diagnostic features include a thick mollic epipedon (Pachic) and an argillic horizon (zone of clay accumulation). The surface structure is weak fine granular. Due to the low amount of rock fragments, loamy soil textures, and enrichment of organic matter from the prevalence of fine roots, these soils tend to have a high water-holding capacity. There may be a very thin organic matter layer on the soil surface, usually less than 3 cm thick.

Associated sites

EX043B15J952	**Subalpine Windswept Shallow Meadow 25-30" PZ Cryic Northern Rocky Mountain Front** The 43B Subalpine Windswept Shallow Meadow ecological site occurs in the subalpine at elevations ranging 1,700-2,300 meters (5,575-7,550 feet), on moderately sloping (15-35%) backslope positions on knobs, ridges and slopes on mountain slopes, mainly on southeasterly aspects. This ecological site is found in small patches rather than large, broad expanses. The soils of 43B Subalpine Windswept Shallow Meadow are well drained and shallow to bedrock. Soil parent materials are colluvium or till over metasedimentary bedrock residuum. Surface textures are typically very gravelly having 35 to 60 percent gravel. Subsurface textures also contain greater than 35 percent rock fragments, are loamy causing these soils fall into the loamy-skeletal particle-size family. A very thin layer (0-5cm) or no organic material is typically present at the soil surface. There are no water table, ponding, flooding or redoximorphic features in these soils. Due to the shallow depth of the soil profile the water-holding capacity of these soils is very limited and the soils will dry down rapidly between precipitation events during extended dry periods. These soils classified in the soil order of Inceptisols. 43B Subalpine Windswept Shallow Meadow has a reference vegetation community of kinnikinnick(Arctostaphylos uva-ursi), (common juniper(Juniperus communis), shrubby cinquefoil(Dasiphora fruticosa), rosa species), rough fescue(Festuca campestris), pinegrass(Calamagrostis rubescens), yarrow(Achillea millefolia), rosy pussytoes(Antennaria rosea), Ross’s sedge (Carex rossii), northern bedstraw(Galium boreale), sulphur-flower buckwheat(Eriogonum umbellatum).
EX043B15I953	**Montane Deciduous Clayey Outwash Terrace 20-24" PZ Cryic Northern Rocky Mountain Front** The 43B Montane deciduous clayey outwash terrace ecological site is found on low to moderate slopes (most range from 5-10 percent, and a few range between 20-35 percent) with southerly (southeastern, southern, southwestern) aspects on backslope, footslope, or toeslope positions of lateral (or ground) moraines from 1,400-1,900 meters (4,600-6,200 feet) elevation.The 43B Montane Deciduous Clayey Outwash Terrace, (aspen) ecological site has soils associated with this ecological site that are very deep and moderately well or well drained. The parent material on these lateral moraine and ground moraine landforms is predominantly glacial till. Subsurface textures are typically in the fine particle-size class families. Dark soil surface horizons enriched with organic matter indicate that the most common soil order for these soils are Mollisols.The 43B Montane Deciduous Clayey Outwash Terrace, (aspen) ecological site has a reference vegetation community of Quaking aspen overstory with an understory of Saskatoon serviceberry, common snowberry, common cowparsnip-western sweetroot and mountain brome.

Similar sites

EX043B15J952	**Subalpine Windswept Shallow Meadow 25-30" PZ Cryic Northern Rocky Mountain Front** These sites are similar in that the reference communities share the same species, though in different abundance, in that native perennial bunchgrasses dominate in the very deep meadow and kinnikinnick and rough fescue can dominate in the windswept shallow meadow due to high winds and shallow soil depth.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Dasiphora fruticosa*
Herbaceous	(1) *Festuca campestris* (2) *Festuca idahoensis*

Legacy ID

R043BX954MT

Physiographic features

This 43B MONTANE VERY DEEP MEADOW ecological site is found in the montane zone, with an elevation range of 1400-2000m, (4,600-6,550 feet), on backslope positions with moderate slopes of 4-15 percent and southwesterly aspects on marginal ground moraines and complex landslides on lateral moraines. Infrequently, this site is found on alluvial fans, hogbacks, knobs, ledges and knolls. These are large patch sized meadows.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

Table 2. Representative physiographic features

Landforms	(1) Mountains > Ground moraine (2) Mountains > Lateral moraine
Elevation	4,593–6,561 ft
Slope	4–15%
Aspect	SE, S, SW

Climatic features

SUMMARY ST. MARY CLIMATE STATION:

Mean Average Precipitation 35-60 inches
Mean Average Annual Temperature 34-43 degrees
Frost free days: 30-70
Relative Effective Annual Precipitation: 33-61 inches

This 43B MONTANE VERY DEEP MEADOW ecological site is found in the cryic soil temperature regime and the udic soil moisture regime. Cryic soils have average annual temperature less than 8 degrees C, with less than 5 degrees C difference from winter to summer. Udic soil moisture regime denotes that the rooting zone is usually moist throughout the winter and the majority of summer. This site is found on the east side of the Continental Divide and has more continental weather influences.

Table 3. Representative climatic features

Frost-free period (characteristic range)	44 days
Freeze-free period (characteristic range)	96 days
Precipitation total (characteristic range)	24-25 in
Frost-free period (actual range)	44 days
Freeze-free period (actual range)	96 days
Precipitation total (actual range)	24-25 in
Frost-free period (average)	44 days
Freeze-free period (average)	96 days
Precipitation total (average)	25 in

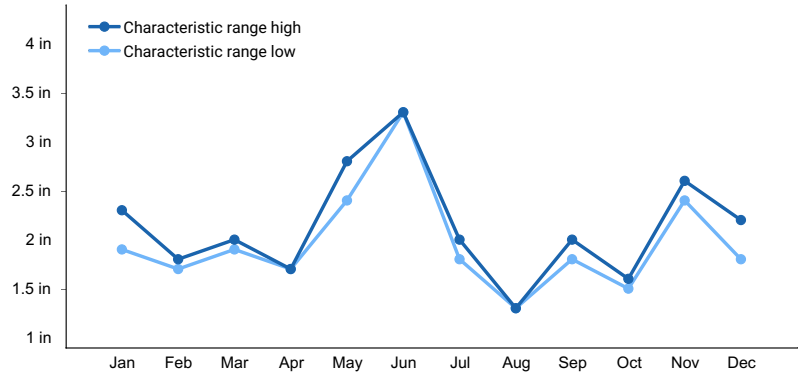


Figure 5. Monthly precipitation range

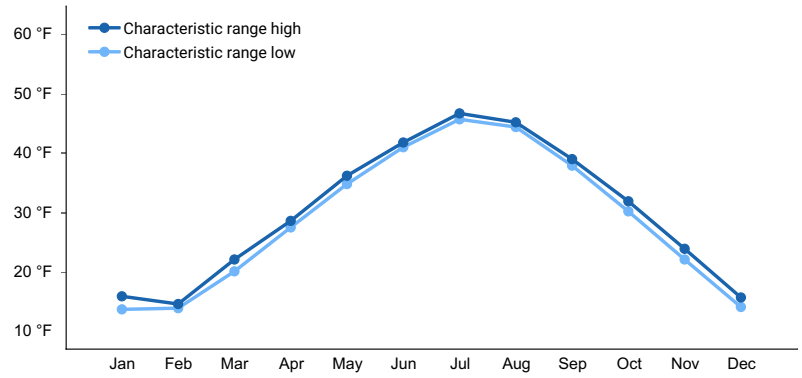


Figure 6. Monthly minimum temperature range

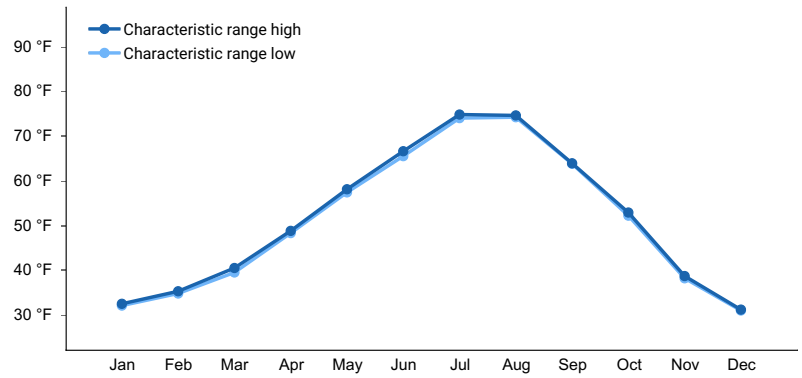


Figure 7. Monthly maximum temperature range

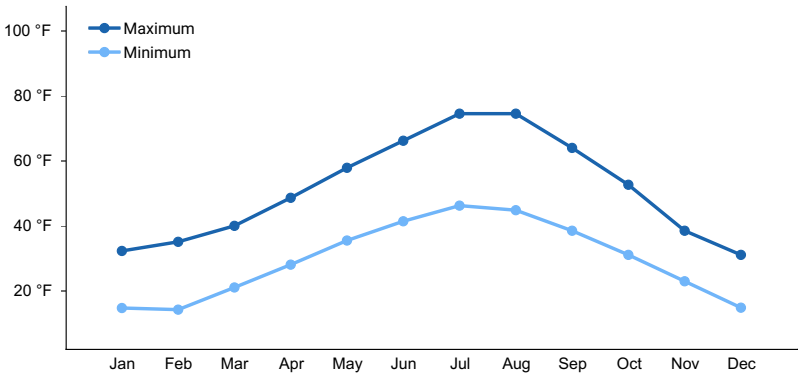


Figure 8. Monthly average minimum and maximum temperature

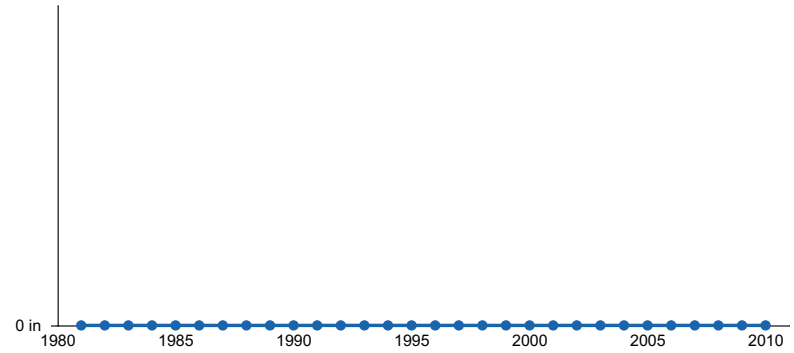


Figure 9. Annual precipitation pattern

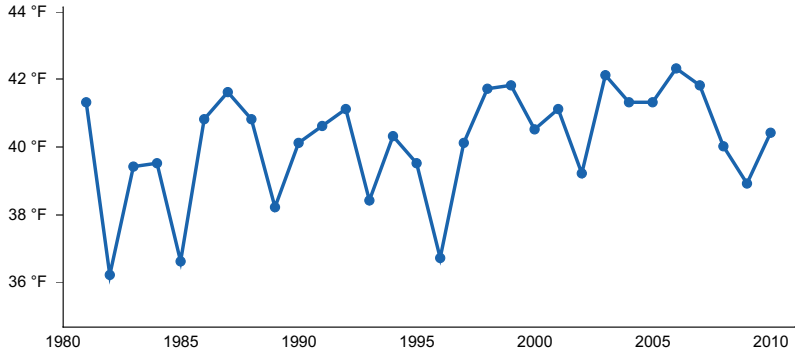


Figure 10. Annual average temperature pattern

Climate stations used

- (1) ST. MARY 1 SSW [USW00004130], Babb, MT
- (2) EAST GLACIER [USC00242629], East Glacier Park, MT

Influencing water features

Soil features

The soils of this ecological site are predominantly very deep and well drained. Surface textures are typically gravelly loam and subsurface layers fall into the fine-loamy particle-size family. These soils are classified in the Mollisols soil order having a thick dark surface with significant enrichment of organic matter and high base saturation. More specifically, these soils are in the Pachic Argicryolls taxonomic subgroup, indicating that the surface layer of dark organic matter-rich mineral soil extends to a depth greater than 40 centimeters and there is an accumulation of clay in the subsoil horizons. The parent material is predominantly till from metamorphic and sedimentary rock. Diagnostic features include a thick mollic epipedon (Pachic) and an argillic horizon (zone of clay accumulation). The surface structure is weak fine granular. Due to the low amount of rock fragments, loamy soil textures, and enrichment of organic matter from the prevalence of fine roots, these soils tend to have a high water-holding capacity. There may be a very thin organic matter layer on the soil surface, usually less than 3 cm thick. For more information on soil taxonomy, please follow this link: http://http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/?cid=nrcs142p2_053580

CORRELATED SOIL SERIES & TAXONOMIC CLASS NAME
Odark Fine-loamy, mixed, superactive Pachic Argicryolls

Figure 11.

Table 4. Representative soil features

Parent material	(1) Till–metasedimentary rock (2) Till–metamorphic rock (3) Mass movement deposits–metasedimentary rock
Surface texture	(1) Gravelly loam
Family particle size	(1) Fine-loamy
Drainage class	Well drained
Permeability class	Moderate
Soil depth	60–100 in
Surface fragment cover <=3"	0–10%
Surface fragment cover >3"	0–10%
Available water capacity (5.1-6.6in)	Not specified
Soil reaction (1:1 water) (5.8-6.6in)	Not specified

Ecological dynamics

Ecological Dynamics of the Site
This ecological site is found in the montane zone, with an elevation range of 1,400-2,000m, on backslope positions with moderate slopes of 4-15 percent and southwesterly aspects on marginal ground moraines and complex landslides on lateral moraines. Infrequently, this site is found on alluvial fans, hogbacks, knobs, ledges and knolls. These are large patch sized meadows. Within the montane lifezone, it is associated with the 43B Montane Deciduous Clayey Outwash Terrace, found on moister site locations. At harsher site locations of this ecological site, it is associated with the
43B Subalpine Windswept Shallow Meadow.

State 1.0
Historic Reference state with no weedy species present.
Rough fescue (*Festuca campestris*)/shrubby cinquefoil (*Dasiphora fruticosa*)/Idaho fescue (*Festuca idahoensis*)/yarrow (Achillea millefolia)-northern bedstraw (*Galium boreale*)-Ross's sedge (*Carex rossii*).

This 43B Montane Very Deep Meadow ecological site is dominated by rough fescue (Festuca campetris) with associated montane grasses and forbs. Idaho fescue (*Festuca idahoensis*) and shrubby cinquefoil are common, but occur in much lower canopy cover. Other associated grasses occurring infrequently but in moderate cover include: rough bentgrass (*Agrostis scabra*), Richardson's needlegrass (*Achnatherum richardsonii*), alpine timothy (*Phleum alpinum*), alpine bluegrass (*Poa alpina*) and blue wildrye (*Elymus glaucus*). Associated montane forbs include:

yarrow (Achillea millefolia), bluebell bellflower (campanula rotundifolia), nineleaf biscuitroot (*Lomatium triternatum*), lupine species and northern bedstraw (*Galium boreale*). Montane shrub species that can occur although in very low cover including: white spirea (Spirea betulifolia), thimbleberry (*Rubus parviflorus*), serviceberry (Amalanchier alnifolia), creeping juniper (*Juniperus horizontalis*), kinnikinnick (*Arctostaphylos uva-ursi*), Wood's rose (*Rosa woodsii*) and sulphur-flower buckwheat (*Eriogonum umbellatum*). This community is predominantly herbaceous with an average total canopy cover of 96 percent and shrub/sub-shrub canopy cover 9 percent relative canopy cover. This relates primarily to the National Park Service Grasslands Report (Asebrook, 2010) classifications of *Festuca campestris*-*Festuca idahoensis*/*Geranium viscosissimum* and *Dasiphora fruticosa*/*Festuca campestris* associations predominantly. Hansen et. al. (1995) found that shrubby cinquefoil, yarrow and northern bedstraw were fair to poor forage for cattle, horses and sheep, whereas Idaho fescue was good forage for all. Shrubby cinquefoil had medium energy value and low protein value for the fall and winter. Idaho fescue had high fall winter energy value and medium protein value. Yarrow and northern bedstraw were low for both energy and protein values in fall and winter. Shrubby cinquefoil was considered poor cover for elk, mule deer, whitetail deer, upland birds, waterfowl, small non-game birds and small mammals. It was fair food value for elk, deer and antelope, but poor for bird species. Yarrow and northern bedstraw were poor food value for elk, deer species and antelope and bird species.

Rough fescue and elk sedge are considered very resistant to human trampling in a study by Cole (1987) assessing human trampling effects on vegetation to recommend campground placement in the backcountry. This is due to its tough core of the tuft (Cole, 1987). The majority of the loss of cover, reduction by 50 percent, occurred in the first 400 passes. Thereafter, cover loss was stabilized from 400-800 passes. The community of rough fescue-timber oatgrass is considered very resistant to both light and heavy trampling. Human trampling is different from wildlife or livestock trampling in the weight of the animal, size, structure and action of a hoof versus a foot.

Rough fescue is a native, cool season, perennial bunchgrass that produces thick mats of persistent sheath and stem bases and culms that grow to 107cm (3.5 feet) and leaf tufts that grow to 41cm (16 inches) in height (Cronquist, 1977). It has extensive fibrous roots to a depth of 122 cm (4 feet), 73 percent of which are concentrated in the top 15 cm (6 inches) of soil (Coupland, 1953). It regenerates from seed, tillers and sometimes rhizomes (Pavlick, 1984). It is well adapted to a short growing season by initiating growth following snowmelt and completes growth before the onset of summer drought. It is very productive and highly palatable to livestock and wildlife. It is used by bighorn sheep, mule deer, elk and bison. It is resistant to moderate grazing but heavy grazing can result in severely decreased root depth and biomass (Aiken, 1990). Grazing can cause a general decline in rough fescue coverage, and is one of the first species to decline with a concomitant increase of common increasers species with grazing such as Idaho fescue, needlegrass species, prairie Junegrass, and Parry's oatgrass.

It is well-adapted to periodic burning and resistant to light fire by their dense, tufted habit. It sprouts from surviving residual plants and colonizes from off-site wind-dispersed seed. Fire may top-kill plants, but cover and production usually is attained in 2-3 years post-fire. Severe damage can occur by hot, mid-summer wildfires (Wright, 1982).

Due to a lack of fire, a shrub-encroached phase does exist that has a high cover of shrub species, including serviceberry (*Amelanchier alnifolia*), kinnikinnick (*Arctostaphylos uva-ursi*), shrubby cinquefoil (*Dasiphora fruticosa*), sulphur-flower buckwheat (*Eriogonum umbellatum*), Wood's rose (*Rosa woodsii*), snowberry (*Symphoricarpos albus*), and thimbleberry (*Rubus parviflorus*). Serviceberry and shrubby cinquefoil dominate the shrub overstory. Infrequent shrub species that can occur include russet buffaloberry (*Shepherdia canadensis*), dwarf bilberry (*Vaccinium cespitosum*), red baneberry (*Actaea rubra*), common juniper (*Juniperus communis*), and creeping barberry (*Mahonia repens*). The understory is dominated by rough fescue (*Festuca campestris*) and low cover of Idaho fescue (*Festuca idahoensis*). This community consists predominantly of herbaceous species ranging from 60-93 percent and averaging 77 percent, and shrub species that range in total average cover from 21-70 percent (39 percent average). There is a very low cover of trees at these sites (2 percent average canopy cover) with a variety of species including lodgepole pine (*Pinus contorta*), black cottonwood (*Populus balsamifera*), and aspen (*Populus tremuloides*).

Invasion Theory

Invasion of weedy species into native vegetation communities requires an understanding of the processes and mechanisms by which an invasion occurs. Resistance and resilience of the native community are essential elements in predicting the success of the invasion. There are two counter point theories on invasive species. The driver theory considers the invasive species to be driving species decline while the passenger model sees the invading species as filling in empty niches left by habitat alteration (Didham, 2005). The passenger model suggests that disturbance is the cause and if stopped, invasion can be reversed. Potential mechanisms of invasion include

theories such as novel weapons, enemy release, competitive superiority, and manipulation of environment. Novel weapons include biological weapons or associations with micro-organisms that allow the invader species to either access new resources or steal them from indigenous plants (Tannas, 2011). Specifically, arbuscular mycorrhizal fungi may provide a substantial competitive advantage to spotted knapweed by carbon parasitism (Carey, 2004). In these cases, the invader uses these weapons to drive the invasion process. Enemy release describes the concept that once invader species are released from their native predator species or chemical warfare within their original community, they are more aggressive in their new community (Blumenthal 2006, Callaway and Aschelhoug 2000). The invader species may have characteristics that allow it to be more competitive than resident plant species such as grazing resistance, adaption to a harsh environment or another competitive ability (Tannas, 2011). Invading species can manipulate the environment to their advantage through resource competition. Mechanisms include modifying light interception, water uptake efficiency or change in soil water holding capacity, nutrient uptake and cycling (D'Antonio and Vitousek, 1992). The final outcome of invasion is establishment of the invading species which occurs as either dominance, coexistence, or exclusion from the indigenous plant community (Seabloom, 2003). D'Antonio and Vitousek (1992) stated grass invasions are particularly important because they are actively moved by humans and exotic grasses compete effectively with native species in many ecosystems. In addition, dominant grasses may change nutrient cycling, modify regional microclimates and alter fire dynamics.

Invasive Species Descriptions

Specifically, scientific literature on invasions by Kentucky bluegrass, smooth brome, spotted knapweed, leafy spurge and Canada thistle into rough fescue grasslands in Canada and Montana will be reviewed. Kentucky bluegrass invasion into rough fescue grasslands can take multiple pathways. Heavy grazing of rough fescue which reduces litter amount combined with timing of defoliation, winter versus growing season and abiotic factors like seasonal variation in soil moisture content can make native grasslands less resistant to invasion (Douwes, 2012, Tannas, 2012). Resilience of the native grassland is dependent on vigor and density of rough fescue and restoration establishment is more successful with cuttings and plugs than seeding (Tannas, 2011). Although, seeding rough fescue as a monoculture is effective (Sherritt, 2012). A study of grazing effects on a rough fescue at Stavely grassland, a Canadian research station, found that heavy grazing pressure by cattle resulted changes in plant species composition to an increase in shallow rooted species, less productive overall, but more resistant to grazing (Dormaar, 1990). In a study of seasonal biomass changes, Willms (1996) found that with grazing intensity the vegetation community composition shifted from one dominated by rough fescue to one dominated by parry oatgrass-Kentucky bluegrass in moderately grazed pastures to Kentucky bluegrass-sedge species in heavily grazed pastures. The rough fescue dominated community had the greatest forage value compared to communities resulting from moderate, heavy and severe grazing (Willms, 1996). More than 20 years of drastically reduced stocking rates were required to enable recovery (Willms, 1985). Soils associated with heavy grazing were transformed to a soil more characteristic of a drier microclimate (Johnston, 1962 and 1971), by reducing the thickness of Ah horizon, reducing percent organic matter and soil moisture and increasing soil temperature with grazing intensity. Heavy grazing also reduced the fertility and soil water holding capacity (Dormaar, 1998). Soil organic matter, and nutrient cycling differed between grazed and ungrazed rough fescue grasslands (Willms, 1988). At a watershed scale, heavy grazing lead to larger summer storm and spring snow melt runoff compared to watersheds with less grazing (Chanasyk, 2002). The quantity and quality of surface runoff from these watersheds showed that grazing posed little risk of nutrient contamination of adjacent streams (Mapfumo, 2002). There was less snow accumulation in heavily and moderately grazed watersheds (Willms, 2006). A study on the effects of grazing on germinable seeds found that soil disturbance in fescue grassland is more likely to lead to a seral community dominated by annual broad-leafed plants, than a rough fescue dominated grassland (Willms, 1995). Skim grazing (light, once-over-spring defoliation) by cattle was not conducive to rough fescue conservation (Moisey, 2005). Rough fescue tolerated light winter-early spring elk grazing but not heavy grazing (Thrift, 2013). A rough fescue grassland in Rumsey Block, Alberta Canada tolerated moderate grazing which resulted in a community co-dominated with shortbristle needle and thread while heavy grazing and/or moderate to major oil and gas disturbance crossed a threshold requiring complete eradication of species and reseeding (Desserud, 2014). Another study of effects of human caused disturbance in rough fescue grasslands in Manitoba Canada, found it depends on invasive species introduction history (Gifford, 2013). Kentucky bluegrass tolerates grazing and can increase in abundance after heavy grazing. Therefore, Kentucky bluegrass resided in historically grazed areas, while smooth brome occurred along roads. In a study of smooth brome on rough fescue grasslands in Saskatchewan Canada, found that it is likely the combination of traits of smooth brome (higher productivity, abundant production of lower quality litter, clonal growth, and greater nutrient uptake capability) that allows it to invade native prairie (Piper, 2015). Smooth brome had a consistent negative impact on community structure and function across 8 grasslands in Alberta Canada with the impact on native species richness higher in species rich areas, while impact on native biomass was larger in productive, warmer and more variable sites (Stotz, 2016).

The noxious weed spotted knapweed was found to strongly reduce the final biomass and reproduction of native

Idaho fescue grasslands. An insect biocontrol agent had little effect on spotted knapweed, while a native fungal pathogen killed it in a common garden experiment in Missoula Montana (Ridenour, 2003). Perry (2005) found that invasion of grasslands by spotted knapweed are mediated by root exudation of catechin, a potent phytotoxin. Catechin resistance was positively correlated with mean seed mass for eight species identified as resistant: Mountain brome, curlycup gumweed, needle and thread grass, basin wildrye, cicer milkvetch, boreal sweetvetch, common blanketflower, and alfalfa. Perry (2005) further found that residual soil catechin may interfere with reestablishment of native grassland species even after spotted knapweed populations are controlled.
Leafy spurge has an extensive rhizomatous root system, potential allelopathic properties and all parts contain high starch latex which seals wounds and is a possible deterrent against insect attacks. Areas with leafy spurge invasion that have been treated with herbicide application and mechanical removal still had higher bare ground area, significantly lower soil arthropod densities and lower plant species richness and cover (Pritekel, 2006). Jordan (2008) found that invasive plants, specifically leafy spurge, smooth brome and crested wheatgrass, are capable of modifying soil microbiota to facilitate further invasion by conspecifics and other invasive species. These soil alterations have the potential to impede restoration of native communities after removal of an invasive species. Successional management may require repeated treatments to achieve a desired outcome. Pokorny (2009) found that while broadleaf herbicide applications decreased hoary cress, Canada thistle and undesired forbs within a leafy spurge invaded site, the results were temporary, and seeding was necessary for native species establishment.

Community Phase 1.1: rough fescue (shrubby cinquefoil/Idaho fescue/yarrow-northern bedstraw-bluebell bellflower
This phase is dominated by rough fescue with associated montane grasses, primarily Idaho fescue, forb species, and shrubs in very low cover, primarily shrubby cinquefoil.

Community Phase 1.2: Saskatoon serviceberry (kinnikinnick-sulphur flower buckwheat)/rough fescue-Idaho fescue/yarrow
This phase is dominated by serviceberry and shrubby cinquefoil in the overstory and by rough fescue in the understory. The same suite of montane shrubs, grasses, and forbs found in Phase 2.1 are found in this phase.

Community Phase Pathway 1.1A
This pathway represents a significant time without fire, such that the historic fire return interval is lengthened, and shrub and conifer species invade.

Community Phase Pathway 1.2A
This pathway represents a resumption of historic fire return intervals, such that woody shrub and conifer encroachment is killed, and grasslands are sustained.

Community Phase 2.1: rough fescue (shrubby cinquefoil/Idaho fescue/yarrow-northern bedstraw-bluebell bellflower
This phase is dominated by rough fescue with associated montane grasses, primarily Idaho fescue, forb species, and shrubs in very low cover, primarily shrubby cinquefoil. This ecological site has high foliar cover (average 81%), low to moderate basal cover (10-15%) and high litter cover (average 85%) under the litter is soil.

Community Phase 2.2
This community has sustained either severe drought or heavy grazing, which has reduced the cover and vigor of rough fescue and increased the cover of Idaho fescue, needlegrass species, and prairie Junegrass. If even these native bunchgrasses decreased significantly, then a transition would occur out of this State 2.

Community Phase 2.3: Saskatoon serviceberry (kinnikinnick-sulphur flower buckwheat)/rough fescue-Idaho fescue/yarrow
This phase is dominated by serviceberry and shrubby cinquefoil in the overstory and by rough fescue in the understory. The same suite of montane shrubs, grasses, and forbs found in Phase 2.1 are found in this phase.

Community Phase Pathway 2.1A
This pathway represents heavy grazing or improper grazing management for sustained periods of time.

Community Phase Pathway 2.2A
This pathway represents a ceasing of heavy grazing or improper grazing management for sustained periods of time.

Community Phase Pathway 2.1B

This pathway represents a significant time without fire, such that the historic fire return interval is lengthened, and shrub and conifer species invade.

Community Phase Pathway 2.3A
This pathway represents a resumption of historic fire return intervals, such that woody shrub and conifer encroachment is killed, and grasslands are sustained.

Transition T1A:
This represents the pathway from the historic Reference state in which there were no weedy species present in the vegetation community (State 1.0), to the introduction and establishment of weedy species, even at very low canopy cover values, within the vegetation community of State 2.0.

Transition T2A:
This pathway represents weed infestation from human, animal, or transportation corridors that allow non-native species to invade and establish within the grassland to the degree that native grass species decline.

Restoration R3A:
This pathway represents proper grazing management that allows the cover and vigor of native bunchgrass, particularly rough fescue, to be restored. Other means such as chemical, mechanical, or biological may be needed to restore native bunchgrass species to dominance.

Summarization of canopy cover data including constancy and canopy cover values (average, minimum and maximum) per species present at community phase 2.1 of this ecological site, 7 sites (includes NPS original data and NRCS revisit vegetation data). Rough fescue (21% average canopy cover) and Idaho fescue (9% average canopy cover) are indicator species for this ecological site with high frequency of occurrence and canopy cover. Other species with high frequency of occurrence include yarrow, shrubby cinquefoil, northern bedstraw and sulphur-flower buckwheat.

Summarization table for foliar cover at community phase 2.1 of this ecological site, 3 NRCS sites. Rough fescue dominates the foliar cover at these sites. Secondarily, Idaho fescue, blue wildrye, shrubby cinquefoil, northern bedstraw and yarrow contribute to foliar cover. Foliar cover is high at these sites (81%) and the ground cover is predominantly litter with soil underneath (85%) and very low bare ground (1%). There is some gravel (10%) and moss (3%). Structure at this vegetation community is composed of three layers. Species in the taller layer (25-51 cm or 10-20 inches) include sticky purple geranium, rough fescue, serviceberry, shrubby cinquefoil, pinegrass, idaho fescue and nineleaf biscuitroot. The middle layer is 15-23 cm or 6-9 inches tall and includes alpine leafybract aster, sulphur-flower buckwheat, northern bedstraw, dwarf bilberry. The lowest layer is 15 cm 6 inches or less and includes yellow penstemon, poa, sedum and vicia species.

Summarization of production in pounds per acre at community phase 2.1 of this ecological site, 2 NRCS sites. Rough fescue dominates the average annual production, secondarily these species contribute: sulphur-flower buckwheat, shrubby cinquefoil, northern bedstraw, Idaho fescue and alpine leafybract aster.
SPECIES TOTAL PRODUCTION AVERAGE= 1651#/ACRE (range= 1514#/acre-1789#/acre) 2SITES

Summarization of canopy cover point data for community phase 2.3 of this ecological site including constancy and canopy cover values per species present at this site, 6 NRCS sites. Species with high constancy occur often, those with low constancy are rare. The average canopy cover is the average of the values for which it occurred. Therefore, species that are rare (only occurred once) show the canopy cover value for the one time it was found. Minimum and maximum canopy cover show the range of cover that the species was found. This is the shrub dominated community phase of this ecological site with serviceberry, sulphur-flower buckwheat and shrubby cinquefoil occurring frequently with moderate to high canopy cover. Infrequently, kinnickinnik and common snowberry occurs with moderate frequency of occurrence and canopy cover.

Foliar cover point data for community phase 2.3 of this ecological site, three NRCS sites. Species with high ranges of foliar cover include shrubby cinquefoil, white spirea, thimbleberry, yellow penstemon, pinegrass, and western meadowrue.

TOTAL FOLIAR COVER 69-99% 3 SITES
SPECIES FOLIAR COVER RANGE IN PERCENT

Summarization of production point data for community phase 2.3 of this ecological site in pounds per acre, at one NRCS site. Rough fescue and dwarf bilberry dominate the average annual production. Species with moderate production include pinegrass, shrubby cinquefoil, pale agoseris, strawberry and lupine species.
SPECIES TOTAL PRODUCTION 1896 1 SITES

State 3.0:
This state represents the community with significant increase in weedy species and concomitant decrease in native grass species.

Community Phase 3.1:
This community phase is dominated by the weedy species phleum pratense, poa pratensis, taraxacum offinale and *Centaurea stoebe* with less amounts of the native vegetation community of this ecological site found in 2.1. Shrubs generally are very low and cover no more than 10 percent of the site. Diverse montane meadow forbs are associated with this site. Tree encroachment is very low, mainly consisting of lodgepole pine at the edges of the prairie.

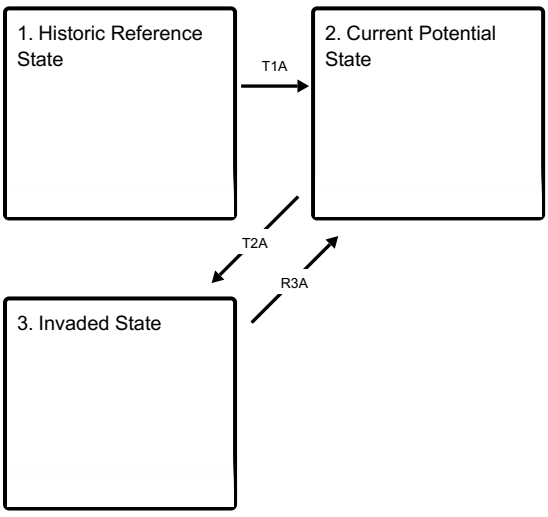
Community Phase 3.2:
This community has sustained shrub or tree encroachment due to a lack of fire, and is dominated by the weedy species phleum pratense, poa pratensis, taraxacum offinale and *Centaurea stoebe* with less amounts of the native vegetation community of this ecological site found in 2.3.

Community Phase Pathway 3.1A
This pathway represents a significant time without fire, such that the historical fire return interval is lengthened, and shrub species invade. Weedy species are still present within the community.

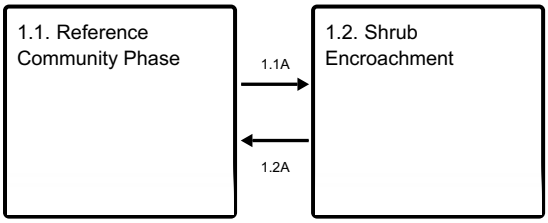
Community Phase Pathway 3.2A
This pathway represents a resumption of historic fire return intervals, such that woody shrub and conifer encroachment is killed, and grasslands are sustained.

State and transition model

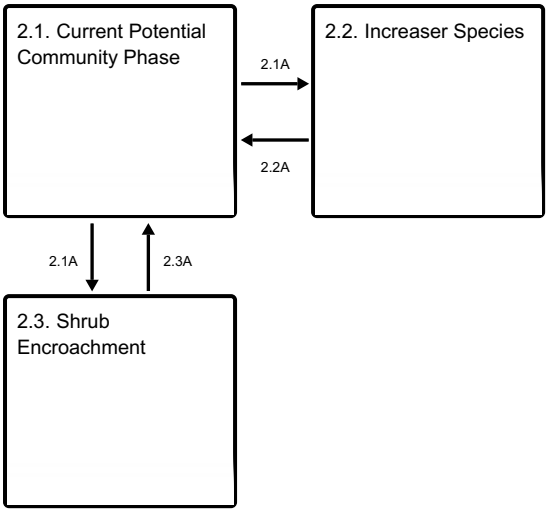
Ecosystem states



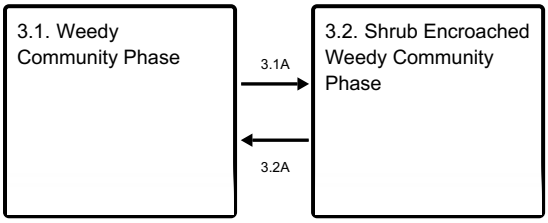
State 1 submodel, plant communities



State 2 submodel, plant communities



State 3 submodel, plant communities



State 1
Historic Reference State

1.0 Historic Reference State with No Weedy Species Present

Community 1.1
Reference Community Phase

Plant Community 1.1 rough fescue (shrubby cinquefoil /Idaho fescue/ yarrow-northern bedstraw- bluebell bellflower)

Community 1.2
Shrub Encroachment

Plant Community 1.2 Shrub Encroachment Shrubby cinquefoil-Saskatoon serviceberry(kinnikinnick-Sulphur-flower buckwheat)/rough fescue-Idaho fescue/yarrow

Pathway 1.1A
Community 1.1 to 1.2

1.1A Significant time without fire, so that the historical fire return interval is lengthened and shrub and conifer species invade.

Pathway 1.2A
Community 1.2 to 1.1

1.2A A resumption of historic fire return intervals, so that woody shrub and conifer encroachments are suppressed, and grasslands are sustained.

State 2
Current Potential State

2.0 Current Potential State With Very Low Cover of Weedy Species

Community 2.1
Current Potential Community Phase

Plant Community 2.1 rough fescue shrubby cinquefoil/Idaho fescue/yarrow-northern bedstraw- bluebell bellflower Community Phase 2.1: rough fescue (shrubby cinquefoil/Idaho fescue/yarrow-northern bedstraw-bluebell bellflower This phase is dominated by rough fescue with associated montane grasses, primarily Idaho fescue, forb species, and shrubs in very low cover, primarily shrubby cinquefoil. This ecological site has high foliar cover (average 81%), low to moderate basal cover (10-15%) and high litter cover (average 85%) under the litter is soil. Summarization of canopy cover data per species present at community phase 2.1 of this ecological site, 7 sites (includes NPS original data and NRCS revisit vegetation data). Rough fescue (21% average canopy cover) and Idaho fescue (9% average canopy cover) are indicator species for this ecological site with high frequency of occurrence and canopy cover. Other species with high frequency of occurrence include yarrow, shrubby cinquefoil, northern bedstraw and sulphur-flower buckwheat. Summarization table for foliar cover at community phase 2.1 of this ecological site, 3 NRCS sites. Total foliar cover range is 76 percent to 88 percent. Rough fescue dominates the foliar cover at these sites. Secondarily, Idaho fescue, blue wildrye, shrubby cinquefoil, northern bedstraw and yarrow contribute to foliar cover. Foliar cover is high at these sites (81%) and the ground cover is predominantly litter with soil underneath (85%) and very low bare ground (1%). There is some gravel (10%) and moss (3%). Structure at this vegetation community is composed of three layers. Species in the taller layer (25-51 cm or 10-20 inches) include sticky purple geranium, rough fescue, serviceberry, shrubby cinquefoil, pinegrass, idaho fescue and nineleaf biscuitroot. The middle layer is 15-23 cm or 6-9 inches tall and includes alpine leafybract aster, sulphur-flower buckwheat, northern bedstraw, dwarf bilberry. The lowest layer is 15 cm 6 inches or less and includes yellow penstemon, poa, sedum and vicia species. Summarization of production in pounds per acre at community phase 2.1 of this ecological site, 2 NRCS sites. Total production averages 1651 and ranges 1514 to 1789 pounds per acre. Rough fescue dominates the average annual production, secondarily these species contribute: sulphur-flower buckwheat, shrubby cinquefoil, northern bedstraw, Idaho fescue and alpine leafybract aster.

Dominant plant species

- shrubby cinquefoil (*Dasiphora fruticosa*), shrub
- rough fescue (*Festuca campestris*), grass
- Idaho fescue (*Festuca idahoensis*), grass
- common yarrow (*Achillea millefolium*), other herbaceous
- northern bedstraw (*Galium boreale*), other herbaceous
- bluebell bellflower (*Campanula rotundifolia*), other herbaceous

Table 5. Ground cover

Tree foliar cover	0-5%
Shrub/vine/liana foliar cover	0-20%
Grass/grasslike foliar cover	30-80%
Forb foliar cover	10-30%
Non-vascular plants	0-5%
Biological crusts	0-1%
Litter	40-60%
Surface fragments >0.25" and <=3"	0-10%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-5%

Table 6. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0-5%
Grass/grasslike basal cover	10-20%
Forb basal cover	5-10%

Non-vascular plants	0-5%
Biological crusts	0-2%
Litter	40-60%
Surface fragments >0.25" and <=3"	0-10%
Surface fragments >3"	0-10%
Bedrock	0%
Water	0%
Bare ground	0-5%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-10%	0-10%	0-20%
>0.5 <= 1	–	0-10%	5-30%	5-20%
>1 <= 2	–	0-10%	5-30%	0-10%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 2.2
Increaser Species

Plant Community 2.2 Degraded, increasing Idaho fescue, needlegrasses, prairie Junegrass, Parry’s oatgrass, decreasing rough fescue.

Community 2.3
Shrub Encroachment

Plant Community 2.3 Shrub Encroachment Shrubby cinquefoil-Saskatoon serviceberry (kinnikinnick-Sulphur-flower buckwheat)/ rough fescue-Idaho fescue/yarrow Summarization of canopy cover point data for community phase 2.3 of this ecological site per species present at this site, 6 NRCS sites. Minimum and maximum canopy cover show the range of cover that the species was found. This is the shrub dominated community phase of this ecological site with serviceberry, sulphur-flower buckwheat and shrubby cinquefoil occurring frequently with moderate to high canopy cover. Infrequently, kinnickinnik and common snowberry occurs with moderate frequency of occurrence and canopy cover. Foliar cover point data for community phase 2.3 of this ecological site, three NRCS sites. Species with high ranges of foliar cover include shrubby cinquefoil, white spirea, thimbleberry, yellow penstemon, pinegrass, and western meadowrue. Summarization of production point data for community phase 2.3 of this ecological site in pounds per acre, at one NRCS site with a total production of 1900 pounds per acre. Rough fescue and dwarf bilberry dominate the average annual production. Species with moderate production include pinegrass, shrubby cinquefoil, pale agoseris, strawberry and lupine species.

Dominant plant species

- shrubby cinquefoil (*Dasiphora fruticosa*), shrub
- Saskatoon serviceberry (*Amelanchier alnifolia*), shrub
- kinnikinnick (*Arctostaphylos uva-ursi*), shrub
- sulphur-flower buckwheat (*Eriogonum umbellatum*), shrub
- rough fescue (*Festuca campestris*), grass
- Idaho fescue (*Festuca idahoensis*), grass
- common yarrow (*Achillea millefolium*), other herbaceous

Table 8. Ground cover

Tree foliar cover	0-5%
Shrub/vine/liana foliar cover	0-20%
Grass/grasslike foliar cover	20-60%
Forb foliar cover	10-30%
Non-vascular plants	0-5%
Biological crusts	0-1%
Litter	50-80%
Surface fragments >0.25" and <=3"	0-10%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 9. Soil surface cover

Tree basal cover	0-2%
Shrub/vine/liana basal cover	0-10%
Grass/grasslike basal cover	10-30%
Forb basal cover	0-10%
Non-vascular plants	0-5%
Biological crusts	0-1%
Litter	50-80%
Surface fragments >0.25" and <=3"	0-10%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0-2%	0-10%	5-20%	0-10%
>0.5 <= 1	0-2%	0-10%	5-20%	0-10%
>1 <= 2	0-2%	0-20%	20-40%	0-10%
>2 <= 4.5	–	–	–	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Pathway 2.1A
Community 2.1 to 2.2

2.1A Heavy grazing or improper grazing management for sustained periods of time.

Pathway 2.1A
Community 2.1 to 2.3

Current Potential Community Phase

Shrub Encroachment

2.1A Heavy grazing or improper grazing management for sustained periods of time.

Pathway 2.2A
Community 2.2 to 2.1

2.2A A ceasing of heavy grazing or improper grazing management for sustained periods of time.

Pathway 2.3A

Community 2.3 to 2.1

Shrub Encroachment

Current Potential Community Phase

2.3A A resumption of historic fire return intervals, so that woody shrub and conifer encroachments are suppressed, and grasslands are sustained.

State 3
Invaded State

Invaded State

Community 3.1
Weedy Community Phase

Plant Community 3.1 timothy-Kentucky bluegrass (rough fescue-Idaho fescue)/dandelion-spotted knapweed (prairie smoke-sticky geranium)

Community 3.2
Shrub Encroached Weedy Community Phase

Plant Community 3.2 Saskatoon serviceberry-kinnikinnick-mountain big sagebrush-shrubby cinquefoil-common juniper-Wood's rose-snowberry-dwarf huckleberry/timothy-Kentucky bluegrass (rough fescue-Idaho fescue)/dandelion-spotted knapweed (prairie smoke-sticky geranium)

Pathway 3.1A
Community 3.1 to 3.2

3.1A Significant time without fire, so that the historical fire return interval is lengthened and shrub species invade.

Pathway 3.2A
Community 3.2 to 3.1

3.2A Resumption of historic fire return intervals, so that woody shrub and conifer encroachments are suppressed, and grasslands are sustained.

Transition T1A
State 1 to 2

T1A The introduction and establishment of weedy species, even at very low canopy cover values.

Transition T2A
State 2 to 3

T2A Weed infestation from human, animal, or transportation corridors that allow non-native species to invade and establish within the grassland to the degree that native grass species decline.

Restoration pathway R3A
State 3 to 2

R3A Proper grazing management that allows the cover and vigor of native bunchgrass, particularly rough fescue, to be restored. Other means such as chemical, mechanical, or biological may be needed to restore native bunchgrass species to dominance.

Additional community tables

Table 11. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Grasses and sedges**			–	
	rough fescue	FECA4	*Festuca campestris*	0–1000	0–50
	Idaho fescue	FEID	*Festuca idahoensis*	0–200	0–30
	timber oatgrass	DAIN	*Danthonia intermedia*	0–20	0–2
	spike trisetum	TRSP2	*Trisetum spicatum*	0–20	0–
	rough bentgrass	AGSC5	*Agrostis scabra*	0–	0–25
	blue wildrye	ELGL	*Elymus glaucus*	0–	0–20
	sedge	CAREX	*Carex*	0–	0–2
Shrub/Vine					
2	**Shrubs and subshrubs**			–	
	sulphur-flower buckwheat	ERUM	*Eriogonum umbellatum*	0–500	0–15
	shrubby cinquefoil	DAFR6	*Dasiphora fruticosa*	0–250	0–20
	pussytoes	ANTEN	*Antennaria*	0–100	0–4
	thimbleberry	RUPA	*Rubus parviflorus*	0–	0–10
	rose meadowsweet	SPSPS	*Spiraea splendens var. splendens*	0–	0–5
	prickly currant	RILA	*Ribes lacustre*	0–	0–2
Forb					
3	**Perennial and annual forbs**			–	
	northern bedstraw	GABO2	*Galium boreale*	0–300	0–25
	alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	0–250	0–5
	nineleaf biscuitroot	LOTR2	*Lomatium triternatum*	0–120	0–1
	common yarrow	ACMI2	*Achillea millefolium*	0–100	0–15
	pale agoseris	AGGL	*Agoseris glauca*	0–100	0–
	yellow penstemon	PECO6	*Penstemon confertus*	0–70	0–5
	silver cinquefoil	POAR8	*Potentilla argentea*	0–70	0–5
	lupine	LUPIN	*Lupinus*	0–50	0–3
	sandwort	ARENA	*Arenaria*	0–40	0–15
	bluebell bellflower	CARO2	*Campanula rotundifolia*	0–40	0–2
	Virginia strawberry	FRVI	*Fragaria virginiana*	0–40	0–
	wormleaf stonecrop	SEST2	*Sedum stenopetalum*	0–40	0–
	pale agoseris	AGGL	*Agoseris glauca*	0–25	0–
	white sweetvetch	HESU	*Hedysarum sulphurescens*	0–25	0–
	aster	ASTER	*Aster*	0–20	0–3
	Pacific anemone	ANMU	*Anemone multifida*	0–15	0–2
	pointedtip mariposa lily	CAAP	*Calochortus apiculatus*	0–5	0–
	Eaton's aster	SYEA2	*Symphyotrichum eatonii*	0–	0–6
	fireweed	CHAN9	*Chamerion angustifolium*	0–	0–6
	woolly groundsel	PACA15	*Packera cana*	0–	0–2
	heartleaf arnica	ARCO9	*Arnica cordifolia*	0–	0–2

	heartleaf arnica	ARCO9	*Arnica cordifolia*	0–	0–2
	broadleaf arnica	ARLA8	*Arnica latifolia*	0–	0–2
	Lyall's angelica	ANAR3	*Angelica arguta*	0–	0–2
	boat thatching grass	HYCY2	*Hyparrhenia cymbaria*	0–	0–1
	desertparsley	LOMAT	*Lomatium*	0–	0–1
	rocky ragwort	SEME	*Senecio megacephalus*	0–	0–1

Table 12. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
rough fescue	FECA4	*Festuca campestris*	Native	–	10.3–60
timber oatgrass	DAIN	*Danthonia intermedia*	Native	–	0.5–23.6
Idaho fescue	FEID	*Festuca idahoensis*	Native	–	1–20
Richardson's needlegrass	ACRI8	*Achnatherum richardsonii*	Native	–	0–15
prairie Junegrass	KOMA	*Koeleria macrantha*	Native	–	0–15
alpine timothy	PHAL2	*Phleum alpinum*	Native	–	0–15
alpine bluegrass	POAL2	*Poa alpina*	Native	–	0–15
rough bentgrass	AGSC5	*Agrostis scabra*	Native	–	0–10
mountain brome	BRMA4	*Bromus marginatus*	Native	–	0–5
green needlegrass	NAVI4	*Nassella viridula*	Native	–	0–3
timothy	PHPR3	*Phleum pratense*	Introduced	–	0–0.8
creeping juniper	JUHO2	*Juniperus horizontalis*	Native	–	0–0.5
Hitchcock's smooth woodrush	LUGLH	*Luzula glabrata var. hitchcockii*	Native	–	0–0.5
sedge	CAREX	*Carex*	Native	–	0–0.5
Canada bluegrass	POCO	*Poa compressa*	Native	–	0–0.5
intermediate wheatgrass	THIN6	*Thinopyrum intermedium*	Introduced	–	0–0.5
spike trisetum	TRSP2	*Trisetum spicatum*	Native	–	0–0.5
Liddon sedge	CAPE7	*Carex petasata*	Native	–	0–0.3
obtuse sedge	CAOB4	*Carex obtusata*	Native	–	0–0.1
arctic rush	JUAR2	*Juncus arcticus*	Native	–	0–0.1
fowl bluegrass	POPA2	*Poa palustris*	Native	–	–
bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	Native	–	–
Forb/Herb					
lupine	LUPIN	*Lupinus*	Native	–	0–37.5
western stoneseed	LIRU4	*Lithospermum ruderale*	Native	–	0–15
blanketflower	GAAR	*Gaillardia aristata*	Native	–	0–15
northern bedstraw	GABO2	*Galium boreale*	Native	–	0–15
pointedtip mariposa lily	CAAP	*Calochortus apiculatus*	Native	–	0–15
blue wildrye	ELGL	*Elymus glaucus*	Native	–	0–10
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	Native	–	0–10
nineleaf biscuitroot	LOTR2	*Lomatium triternatum*	Native	–	0–8
Eaton's aster	SYEA2	*Symphyotrichum eatonii*	Native	–	0–7
pale agoseris	AGGL	*Agoseris glauca*	Native	–	0–7
yellow penstemon	PECO6	*Penstemon confertus*	Native	–	0–6.1
common yarrow	ACMI2	*Achillea millefolium*	Native		0–5

common yarrow	ACMI2	*Achillea millefolium*	Native	–	0–5
Lyall's angelica	ANAR3	*Angelica arguta*	Native	–	0–5
roundleaf alumroot	HECY2	*Heuchera cylindrica*	Native	–	0–5
fireweed	CHAN9	*Chamerion angustifolium*	Native	–	0–5
rosy pussytoes	ANRO2	*Antennaria rosea*	Native	–	0–5
broadleaf arnica	ARLA8	*Arnica latifolia*	Native	–	0–5
Sitka valerian	VASI	*Valeriana sitchensis*	Native	–	0–5
rocky ragwort	SEME	*Senecio megacephalus*	Native	–	0–5
cinquefoil	POTEN	*Potentilla*	Native	–	0–3
silver cinquefoil	POAR8	*Potentilla argentea*	Introduced	–	0–3
American bistort	POBI6	*Polygonum bistortoides*	Native	–	0–3
vetch	VICIA	*Vicia*	Native	–	0–3
mountain deathcamas	ZIEL2	*Zigadenus elegans*	Native	–	0–3
stonecrop	SEDUM	*Sedum*	Native	–	0–3
sandwort	ARENA	*Arenaria*	Native	–	0–3
bluebell bellflower	CARO2	*Campanula rotundifolia*	Native	–	0–3
Indian paintbrush	CASTI2	*Castilleja*	Native	–	0–3
sulphur-flower buckwheat	ERUM	*Eriogonum umbellatum*	Native	–	0–3
strawberry	FRAGA	*Fragaria*	Native	–	0–3
woodland strawberry	FRVE	*Fragaria vesca*	Native	–	0–3
Virginia strawberry	FRVI	*Fragaria virginiana*	Native	–	0–3
desertparsley	LOMAT	*Lomatium*	Native	–	0–3
smallflower woodland-star	LIPA5	*Lithophragma parviflorum*	Native	–	0–3
pearly pussytoes	ANAN2	*Antennaria anaphaloides*	Native	–	0–2.3
western meadow-rue	THOC	*Thalictrum occidentale*	Native	–	0–2
slender cinquefoil	POGR9	*Potentilla gracilis*	Native	–	0–2
Bonneville shootingstar	DOCO	*Dodecatheon conjugens*	Native	–	0–1.4
American vetch	VIAM	*Vicia americana*	Native	–	0–1.2
spearleaf stonecrop	SELA	*Sedum lanceolatum*	Native	–	0–1
bastard toadflax	COUM	*Comandra umbellata*	Native	–	0–1
Drummond's rockcress	ARDR	*Arabis drummondii*	Native	–	0–1
pussytoes	ANTEN	*Antennaria*	Native	–	0–1
western pearly everlasting	ANMA	*Anaphalis margaritacea*	Native	–	0–1
white sweetvetch	HESU	*Hedysarum sulphurescens*	Native	–	0–1
Pacific anemone	ANMU	*Anemone multifida*	Native	–	0–0.9
field chickweed	CEAR4	*Cerastium arvense*	Native	–	0–0.8
Missouri goldenrod	SOMI2	*Solidago missouriensis*	Native	–	0–0.8
Rocky Mountain goldenrod	SOMU	*Solidago multiradiata*	Native	–	0–0.6
yellow salsify	TRDU	*Tragopogon dubius*	Introduced	–	0–0.5
common dandelion	TAOF	*Taraxacum officinale*	Introduced	–	0–0.5
green false hellebore	VEVI	*Veratrum viride*	Native	–	0–0.5
yellow rattle	RHINA	*Rhinanthus*	Native	–	0–0.5
wormleaf stonecrop	SEST2	*Sedum stenopetalum*	Native	–	0–0.5
bladder campion	SILA21	*Silene latifolia*	Introduced	–	0–0.5

Parry's silene	SIPA4	*Silene parryi*	Native	–	0–0.5
spotted knapweed	CEST8	*Centaurea stoebe*	Introduced	–	0–0.5
rockcress	ARABI2	*Arabis*	Native	–	0–0.5
arnica	ARNIC	*Arnica*	Native	–	0–0.5
milkvetch	ASTRA	*Astragalus*	Native	–	0–0.5
common cowparsnip	HEMA80	*Heracleum maximum*	Native	–	0–0.5
wild chives	ALSC	*Allium schoenoprasum*	Native	–	0–0.5
old man's whiskers	GETR	*Geum triflorum*	Native	–	0–0.5
sticky purple geranium	GEVI2	*Geranium viscosissimum*	Native	–	0–0.5
beardtongue	PENST	*Penstemon*	Native	–	0–0.5
yellow owl's-clover	ORLU2	*Orthocarpus luteus*	Native	–	0–0.5
woolly groundsel	PACA15	*Packera cana*	Native	–	0–0.5
bracted lousewort	PEBR	*Pedicularis bracteosa*	Native	–	0–0.5
coiled lousewort	PECO	*Pedicularis contorta*	Native	–	0–0.5
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	Native	–	0–0.4
Wyoming besseya	BEWY	*Besseya wyomingensis*	Native	–	0–0.3
small camas	CAQU2	*Camassia quamash*	Native	–	0–0.3
woolly cinquefoil	POHI6	*Potentilla hippiana*	Native	–	0–0.3
Yellowstone saxifrage	SASU6	*Saxifraga subapetala*	Native	–	0–0.1
smooth blue aster	SYLA3	*Symphyotrichum laeve*	Native	–	0–0.1
Cusick's Indian paintbrush	CACU7	*Castilleja cusickii*	Native	–	0–0.1
American thorow wax	BUAM2	*Bupleurum americanum*	Native	–	0–0.1
Nuttall's rockcress	ARNU	*Arabis nuttallii*	Native	–	0–0.1
aspen fleabane	ERSP4	*Erigeron speciosus*	Native	–	0–0.1
Fern/fern ally					
common moonwort	BOLU	*Botrychium lunaria*	Native	–	0–0.1
Shrub/Subshrub					
shrubby cinquefoil	DAFR6	*Dasiphora fruticosa*	Native	–	0.5–20
kinnikinnick	ARUV	*Arctostaphylos uva-ursi*	Native	–	0–3
Woods' rose	ROWO	*Rosa woodsii*	Native	–	0–3
prickly rose	ROAC	*Rosa acicularis*	Native	–	0–1.4
thimbleberry	RUPA	*Rubus parviflorus*	Native	–	0–1
rose meadowsweet	SPSPS	*Spiraea splendens var. splendens*	Native	–	0–1
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	Native	–	0–1
common snowberry	SYAL	*Symphoricarpos albus*	Native	–	0–0.5
Nonvascular					
Moss	2MOSS	*Moss*	Native	–	0–3
spikemoss	SELAG	*Selaginella*	Native	–	0–0.3

Table 13. Community 2.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Grasses and sedges and woodrushes**			–	
	rough fescue	FEGA4	*Festuca campestris*	100–700	0–3

	rough fescue	FECA4	*Festuca campestris*	100–700	0–3
	pinegrass	CARU	*Calamagrostis rubescens*	0–400	0–20
	alpine bluegrass	POAL2	*Poa alpina*	0–30	–
	Kentucky bluegrass	POPR	*Poa pratensis*	0–20	–
	timber oatgrass	DAIN	*Danthonia intermedia*	0–10	–
	sedge	CAREX	*Carex*	–	0–15
	Richardson's needlegrass	ACRI8	*Achnatherum richardsonii*	–	0–8
	Idaho fescue	FEID	*Festuca idahoensis*	–	0–6
	Hitchcock's smooth woodrush	LUGLH	*Luzula glabrata var. hitchcockii*	–	0–5
	mountain brome	BRMA4	*Bromus marginatus*	–	0–5
Shrub/Vine					
2	**Shrubs and subshrubs**			–	
	dwarf bilberry	VACE	*Vaccinium cespitosum*	0–700	0–3
	shrubby cinquefoil	DAFR6	*Dasiphora fruticosa*	0–250	0–30
	Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	0–70	0–12
	thimbleberry	RUPA	*Rubus parviflorus*	–	0–25
	sulphur-flower buckwheat	ERUM	*Eriogonum umbellatum*	–	0–15
	pussytoes	ANTEN	*Antennaria*	–	0–5
	red baneberry	ACRU2	*Actaea rubra*	–	0–1
	white spirea	SPBE2	*Spiraea betulifolia*	–	–
Forb					
3	**Perennial and annual forbs**			–	
	Virginia strawberry	FRVI	*Fragaria virginiana*	0–300	0–7
	lupine	LUPIN	*Lupinus*	0–300	0–3
	pale agoseris	AGGL	*Agoseris glauca*	0–300	–
	yellow penstemon	PECO6	*Penstemon confertus*	0–140	0–20
	silver cinquefoil	POAR8	*Potentilla argentea*	0–140	–
	ragwort	SENEC	*Senecio*	0–130	0–1
	nineleaf biscuitroot	LOTR2	*Lomatium triternatum*	0–100	0–2
	northern bedstraw	GABO2	*Galium boreale*	0–60	0–7
	common yarrow	ACMI2	*Achillea millefolium*	0–50	0–10
	western meadow-rue	THOC	*Thalictrum occidentale*	0–30	0–25
	western pearly everlasting	ANMA	*Anaphalis margaritacea*	0–30	0–5
	sandwort	ARENA	*Arenaria*	0–20	–
	bluebell bellflower	CARO2	*Campanula rotundifolia*	0–5	–
	common dandelion	TAOF	*Taraxacum officinale*	0–5	–
	alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	0–	0–10
	fireweed	CHAN9	*Chamerion angustifolium*	0–	0–7
	white thistle	CIHO	*Cirsium hookerianum*	0–	0–6
	common cowparsnip	HEMA80	*Heracleum maximum*	0–	0–4
	coiled lousewort	PECO	*Pedicularis contorta*	0–	0–4
	splitleaf Indian paintbrush	CARH4	*Castilleja rhexiifolia*	0–	0–3
	Lyall's angelica	ANAR3	*Angelica arguta*	0–	0–3
	Queen Anne's lace	DACA6	*Daucus carota*	0–	0–2

	Queen Anne's lace	DACA6	*Daucus carota*	0–	0–2
	white sweetvetch	HESU	*Hedysarum sulphurescens*	0–	0–2
	helianthella	HELIA	*Helianthella*	0–	0–2
	Sitka valerian	VASI	*Valeriana sitchensis*	0–	0–1
	violet	VIOLA	*Viola*	0–	0–1
	western sweetroot	OSOC	*Osmorhiza occidentalis*	0–	0–1
	catchfly	SILEN	*Silene*	0–	0–1
	Rocky Mountain goldenrod	SOMU	*Solidago multiradiata*	0–	0–1
	Rocky Mountain iris	IRMI	*Iris missouriensis*	0–	0–1
	sticky purple geranium	GEVI2	*Geranium viscosissimum*	0–	0–1
	Jessica sticktight	HAMI	*Hackelia micrantha*	0–	0–1
	white sagebrush	ARLU	*Artemisia ludoviciana*	0–	0–1

Table 14. Community 2.3 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
rough fescue	FECA4	*Festuca campestris*	–	–	0–37.5
Idaho fescue	FEID	*Festuca idahoensis*	–	–	0–15
Kentucky bluegrass	POPR	*Poa pratensis*	–	–	0–10
mountain brome	BRMA4	*Bromus marginatus*	–	–	0–5
sedge	CAREX	*Carex*	–	–	0–5
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0–3
Richardson's needlegrass	ACRI8	*Achnatherum richardsonii*	–	–	0–3
bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	–	–	0–3
timothy	PHPR3	*Phleum pratense*	–	–	0–2
Hitchcock's smooth woodrush	LUGLH	*Luzula glabrata var. hitchcockii*	–	–	0–2
alpine timothy	PHAL2	*Phleum alpinum*	–	–	0–1
alpine bluegrass	POAL2	*Poa alpina*	–	–	0–0.5
prairie Junegrass	KOMA	*Koeleria macrantha*	–	–	0–0.5
timber oatgrass	DAIN	*Danthonia intermedia*	–	–	0–0.5
Forb/Herb					
cinquefoil	POTEN	*Potentilla*	–	–	0–37.5
lupine	LUPIN	*Lupinus*	–	–	0–15
Indian paintbrush	CASTI2	*Castilleja*	–	–	0–15
Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	0–10
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0–7
splitleaf Indian paintbrush	CARH4	*Castilleja rhexiifolia*	–	–	0–7
Lyall's angelica	ANAR3	*Angelica arguta*	–	–	0–5
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0–5
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0–5
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	0–4
common beargrass	XETE	*Xerophyllum tenax*	–	–	0–3
Scouler's woollyweed	HISC2	*Hieracium scouleri*	–	–	0–3
Rocky Mountain iris	IRMI	*Iris missouriensis*	–	–	0–3

roundleaf alumroot	HECY2	*Heuchera cylindrica*	–	–	0–3
helianthella	HELIA	*Helianthella*	–	–	0–3
nineleaf biscuitroot	LOTR2	*Lomatium triternatum*	–	–	0–3
cream pea	LAOC2	*Lathyrus ochroleucus*	–	–	0–3
western stoneseed	LIRU4	*Lithospermum ruderale*	–	–	0–3
slender cinquefoil	POGR9	*Potentilla gracilis*	–	–	0–3
eastern pasqueflower	PUPA5	*Pulsatilla patens*	–	–	0–3
common yarrow	ACMI2	*Achillea millefolium*	–	–	0–3
bluebell bellflower	CARO2	*Campanula rotundifolia*	–	–	0–3
rosy pussytoes	ANRO2	*Antennaria rosea*	–	–	0–3
white thistle	CIHO	*Cirsium hookerianum*	–	–	0–3
knapweed	CENTA	*Centaurea*	–	–	0–3
sulphur-flower buckwheat	ERUM	*Eriogonum umbellatum*	–	–	0–3
western showy aster	EUCO36	*Eurybia conspicua*	–	–	0–3
blanketflower	GAAR	*Gaillardia aristata*	–	–	0–3
northern bedstraw	GABO2	*Galium boreale*	–	–	0–3
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0–3
aster	ASTER	*Aster*	–	–	0–3
sticky purple geranium	GEVI2	*Geranium viscosissimum*	–	–	0–3
woodland strawberry	FRVE	*Fragaria vesca*	–	–	0–2
onion	ALLIU	*Allium*	–	–	0–2
fernleaf biscuitroot	LODI	*Lomatium dissectum*	–	–	0–2
white sweetvetch	HESU	*Hedysarum sulphurescens*	–	–	0–1
little yellow rattle	RHMIM	*Rhinanthus minor ssp. minor*	–	–	0–1
silver cinquefoil	POAR8	*Potentilla argentea*	–	–	0–1
yellow penstemon	PECO6	*Penstemon confertus*	–	–	0–1
pale agoseris	AGGL	*Agoseris glauca*	–	–	0–1
catchfly	SILEN	*Silene*	–	–	0–1
goldenrod	SOLID	*Solidago*	–	–	0–1
common dandelion	TAOF	*Taraxacum officinale*	–	–	0–0.5
sandwort	ARENA	*Arenaria*	–	–	0–0.5
wild chives	ALSC	*Allium schoenoprasum*	–	–	0–0.5
western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	0–0.5
Pacific anemone	ANMU	*Anemone multifida*	–	–	0–0.5
Richardson's geranium	GERI	*Geranium richardsonii*	–	–	0–0.5
Queen Anne's lace	DACA6	*Daucus carota*	–	–	0–0.5
Jessica sticktight	HAMI	*Hackelia micrantha*	–	–	0–0.5
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	0–0.5
Shrub/Subshrub					
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	0–37.5
dwarf bilberry	VACE	*Vaccinium cespitosum*	–	–	0–18
russet buffaloberry	SHCA	*Shepherdia canadensis*	–	–	0–15
kinnikinnick	ARUV	*Arctostaphylos uva-ursi*	–	–	0–15
shrubby cinquefoil	DAFR6	*Dasiphora fruticosa*	–	–	0–15

common snowberry	SYAL	*Symphoricarpos albus*	–	–	0–8
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0–7
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0–7
rose	ROSA5	*Rosa*	–	–	0–3
Woods' rose	ROWO	*Rosa woodsii*	–	–	0–3
creeping barberry	MARE11	*Mahonia repens*	–	–	0–3
white sagebrush	ARLU	*Artemisia ludoviciana*	–	–	0–3
vetch	VICIA	*Vicia*	–	–	0–3
red baneberry	ACRU2	*Actaea rubra*	–	–	0–0.5
common juniper	JUCO6	*Juniperus communis*	–	–	0–0.5
Tree					
quaking aspen	POTR5	*Populus tremuloides*	–	–	0–3
black cottonwood	POBAT	*Populus balsamifera ssp. trichocarpa*	–	–	0–3
lodgepole pine	PICO	*Pinus contorta*	–	–	0–3
whitebark pine	PIAL	*Pinus albicaulis*	–	–	0–0.5
subalpine fir	ABLA	*Abies lasiocarpa*	–	–	0–0.5

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Montana Native Heritage Program Web Page. Rocky Mountain Foothill, valley grassland.

Contributors

Stephanie Shoemaker

Approval

Kirt Walstad, 5/06/2024

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)	
Contact for lead author	
Date	04/29/2024
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

---

2. **Presence of water flow patterns:**

---

3. **Number and height of erosional pedestals or terracettes:**

---

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

---

5. **Number of gullies and erosion associated with gullies:**

---

6. **Extent of wind scoured, blowouts and/or depositional areas:**

---

7. **Amount of litter movement (describe size and distance expected to travel):**

---

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

---

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

---

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

    Dominant:

    Sub-dominant:

    Other:

    Additional:

---

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

---

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

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

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:**

17. **Perennial plant reproductive capability:**