USDA Natural Resources Conservation Service

Ecological site F043AX956MT
Subalpine Coniferous Cool Moderately Dry subalpine fir (Abies lasiocarpa) / Engelmann spruce (Picea engelmannii)

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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): 043A–Northern Rocky Mountains

This MLRA is located in Montana (43 percent), Idaho (34 percent), and Washington (23 percent). It makes up about 31,435 square miles (81,460 square kilometers). It has no large cities or towns. It has many national forests, including the Okanogan, Colville, Kootenai, Lolo, Flathead, Coeur d'Alene, St. Joe, Clearwater, and Kaniksu National Forests.

This MLRA is in the Northern Rocky Mountains Province of the Rocky Mountain System. It is characterized by rugged, glaciated mountains; thrust- and block-faulted mountains; and hills and valleys. Steep-gradient rivers have cut deep canyons. Natural and manmade lakes are common.

The major Hydrologic Unit Areas (identified by four-digit numbers) that make up this MLRA are: Kootenai-Pend Oreille-Spokane (1701), 67 percent; Upper Columbia (1702), 18 percent; and Lower Snake (1706), 15 percent. Numerous rivers originate in or flow through this area, including, the Sanpoil, Columbia, Pend Oreille, Kootenai, St. Joe, Thompson, and Flathead Rivers.

This area is underlain primarily by stacked slabs of layered sedimentary or metasedimentary bedrock. The bedrock formations range from Precambrian to Cretaceous in age. The rocks consist of shale, sandstone, siltstone, limestone, argillite, quartzite, gneiss, schist, dolomite, basalt, and granite. The formations have been faulted and stacked into a series of imbricate slabs by regional tectonic activity. Pleistocene glaciers carved a rugged landscape that includes sculpted hills and narrow valleys filled

with till and outwash. Continental glaciation over road the landscape in the northern half of the MLRA while glaciation in the southern half was confined to montane settings.

The average annual precipitation is 25 to 60 inches (635 to 1,525 millimeters) in most of this area, but it is as much as 113 inches (2,870 millimeters) in the mountains and is 10 to 15 inches (255 to 380 millimeters) in the western part of the area. Summers are dry. Most of the precipitation during fall, winter, and spring is snow. The average annual temperature is 32 to 51 degrees F (0 to 11 degrees C) in most of the area, decreasing with elevation. In most of the area, the freeze-free period averages 140 days and ranges from 65 to 215 days. It is longest in the low valleys of Washington, and it decreases in length with elevation. Freezing temperatures occur every month of the year on high mountains, and some peaks have a continuous cover of snow and ice.

The dominant soil orders in this MLRA are Andisols, Inceptisols, and Alfisols. Many of the soils are influenced by Mount Mazama ash deposits. The soils in the area have a frigid or cryic soil temperature regime; have an ustic, xeric, or udic soil moisture regime; and dominantly have mixed mineralogy. They are shallow to very deep, are very poorly drained to well drained, and have most of the soil texture classes. The soils at the lower elevations include Udivitrands, Vitrixerands and Haplustalfs. The soils at the higher elevations include Dystrocryepts, Eutrocryepts, Vitricryands , and Haplocryalfs. Cryorthents, Cryepts, and areas of rock outcrop are on ridges and peaks above timberline

This area is in the northern part of the Northern Rocky Mountains. Grand fir, Douglas-fir, western red cedar, western hemlock, western larch, lodgepole pine, subalpine fir, ponderosa pine, whitebark pine, and western white pine are the dominant overstory species, depending on precipitation, temperature, elevation, and landform aspect. The understory vegetation varies, also depending on climatic and landform factors. Some of the major wildlife species in this area are whitetailed deer, mule deer, elk, moose, black bear, grizzly bear, coyote, fox, and grouse. Fish, mostly in the trout and salmon families, are abundant in streams, rivers, and lakes.

More than one-half of this area is federally owned and administered by the U.S. Department of Agriculture, Forest Service. Much of the privately-owned land is controlled by large commercial timber companies. The forested areas are used for wildlife habitat, recreation, watershed, livestock grazing, and timber production. Meadows provide summer grazing for livestock and big game animals. Less than 3 percent of the area is cropland.

LRU notes

This ecological site resides in MLRA 43A in the Livingston-Lewis-Apgar Mountains which includes the bulk of Glacier National Park (GNP) and the lower western valley portions along the Flathead River. The landscape is mountains and landforms include glaciated mountains with associated features such as U-shaped valleys, mountain slopes, alpine ridges, cirques, valley floors and moraines. Glaciation of this area was in the form of

alpine, icecaps and valley outlet glaciers. It also includes associated alluvium and outwash features. This area includes low valleys to tall mountains with elevation ranging 989-2,762 m (3,250-9,050 ft.). The climate is cold and wet with mean annual air temperature of 3 degrees Celsius (37 degrees F)., mean frost free days of 65 days and mean annual precipitation of 1295 mm (51 in.) and relative effective annual precipitation is 169 cm (66 in.). The soil temperature regime is cryic and the soil moisture regime is udic. The geology of this area is dominated by metasedimentary rocks of the Belt Supergroup (Grinnell argillite and Siyeh limestone) with minor Tertiary sediments. Soils are generally weakly developed on mountain slopes within U-shaped valleys. Parent materials are commonly of colluvium, till, and residuum from metasedimentary rocks. Limestone bedrock within this part of the Belt Supergroup is not highly calcareous and due to high precipitation received in this area most carbonates at mid and upper elevations have been leached from the soil profiles. Bedrock depth varies greatly with location, landform and slope position. Volcanic ash is often found in the soil surface with various degrees of mixing. Thicker volcanic ash can be found on more stable positions on mid and upper elevation slopes that are protected from wind erosion. Volcanic ash is not typically found in low elevation areas on stream and outwash terraces associated with streams and rivers. There are numerous large lakes including St. Mary, Bowman, Kintla, Lake Sherburne, Logging, Upper Waterton and numerous creeks (

Classification relationships

This ecological site relates to the USFS Habitat Type ABLA/XETE. This site relates to the USFS Habitat Type Group 9 and Fire Group 8. Both of these classification guides are specifically for the western Montana and northern Idaho region.

Ecological site concept

Ecological Site Concept
This site is found in cool, moderately dry mid-elevation areas that span the lower subalpine. It is found primarily on foot and backslope positions on lateral moraine and cirque floor landforms at elevations ranging from 1,300 to 2,600 meters (4,250-8,500 feet) on various slope inclinations ranging from 15 to 80 percent. Subalpine fir (*Abies lasiocarpa*) and, to a lesser amount, Engelmann spruce (*Picea engelmannii*), are the dominant overstory species with lodgepole pine (*Pinus contorta*) and Douglas-fir (*Pseudotsuga menziesii*) as the seral dominants with lesser amounts of western larch (*Larix occidentalis*) and western white pine (*Pinus monticola*). Whitebark pine (*Pinus albicaulis*) may be present, but these sites are not cold enough to give it a competitive advantage and therefore it is a minor component. The main understory species is the indicator species beargrass (*Xerophyllum tenax*), with the medium-sized shrub thinleaf huckleberry (*Vaccinium membranaceum*), grouse whortleberry (*Vaccinium scoparium*), and minor amounts of Oregon boxleaf (*Paxistima myrsinites*) and other understory species of pinegrass (*Calamagrostis rubescens*), Geyers sedge (*Carex geyeri*), broadleaf arnica (*Arnica cordifolia*), western meadow-rue (*Thalictrum occidentale*), and sidebells wintergreen (*Orthilia secunda*). Soils associated with this ecological site are very deep,

well drained and formed in volcanic ash over glacial till or colluvium parent material. The origin of the volcanic ash is from the eruption of Mount Mazama (Crater Lake, Oregon) and occurs as a surface mantle on these soils. Due to the parent materials that these soils form in they generally have many rock fragments in the subsurface below the volcanic ash surface layers. These soils are classified in the Inceptisols soil order and more specifically in the Andic Haplocryepts subgroup. These soils have a volcanic ash layer with andic soil properties, a cambic diagnostic horizon and either an ochric or umbric epipedon (Soil Survey Staff, 2015). Being under forest canopy cover these soils typically have a thin surface layer of organic material, usually less than 5 cm thick.

Associated sites

F043AX954MT	**Upper Subalpine Cold Coniferous subalpine fir (Engelmann spruce) /thinleaf huckleberry-rusty menziesia/ Hitchcock's smooth woodrush-beargrass/yellow avalanche lily.** The 43A Upper Subalpine Cold Coniferous (ABLA/LUGLH) ecological site is found along the continental divide in cold, and moist to moderately dry, high elevations in the upper subalpine. It is primarily on cirque platform and headwall landforms, on backslope and shoulder positions at elevations ranging 1,700 to 2,600 meters (5,575-8,500 feet) with moderate to steep slopes ranging 10% to 80%.The 43A Upper Subalpine Cold Coniferous (ABLA/LUGLH) has soils associated with this ecological site that are moderately deep, well drained and derived from glacial till or colluvium over residuum weathered from metasedimentary rock. Moderately deep depth class indicates that these soils are greater than 50 cm (20 inches) deep, but less than 100 cm (40 inches). These soils classify in the Inceptisols soil order and in the Typic Haplocryepts taxonomic subgroup.
R043AX968MT	**Montane Stable Colluvial Slope Saskatoon serviceberry-common snowberry/Sitka alder/ Rocky mountain maple/thimbleberry/mountain brome-Geyer's sedge** The 43A Montane Stable Colluvial Slope ecological site is found on steep slopes (35-60 percent), on back, foot and toeslope positions on glacial valley wall landforms at elevations ranging from 1,150-2,100 meters (3,775-6,900 feet).The 43A Montane Steep Stable Colluvial Slope has soils that are very deep and well drained soils from till or colluvium from metasedimentary rock parent material. There is a high volume of fragments (50 to 67 percent by volume) within the soil profile. The predominant texture in the surface is very gravelly sandy loam and the subsurface is sandy skeletal. There are no redoximorphic features in the soil and there is rarely an argillic or mollic layer. There is a thin organic layer, usually less than 5 cm thick.

F043AX951MT	**Lower Subalpine Cool Dry Coniferous subalpine fir- Engelmann spruce/ Sitka alder/ thinleaf huckleberry/ common beargrass** The 43A Lower Subalpine Coniferous Cool Moderately Dry, (ABLA/CLUN2-XETE) ecological site is found in cool, moderately dry mid-elevations that span the lower subalpine areas. It is found primarily on lateral moraine and glacial valley wall landforms, on back or footslope positions, at elevations ranging 1,000 to 2,100 meters (3,300-6,900 feet), on all aspects and on moderate to steep slopes ranging 10-35 percent.The 43A Lower Subalpine Coniferous Cool Moderately Dry, (ABLA/CLUN2-XETE) site has soils associated with this Ecological Site that are very deep and well drained. These soils have developed in glacial till or colluvium parent materials derived from metasedimentary rock that typically have varying amounts of influence of volcanic ash in the soil surface layers. The dominant taxonomic soil order associated with these soils is Inceptisols with Andic subgroups indicating that there is 18 to 37 centimeters (7-14.5 inches) of volcanic ash.

Similar sites

F043AX954MT	**Upper Subalpine Cold Coniferous subalpine fir (Engelmann spruce) /thinleaf huckleberry-rusty menziesia/ Hitchcock's smooth woodrush-beargrass/yellow avalanche lily.**

Table 1. Dominant plant species

Tree	(1) *Abies lasiocarpa* (2) *Picea engelmannii*
Shrub	(1) *Lonicera utahensis* (2) *Vaccinium membranaceum*
Herbaceous	(1) *Thalictrum occidentale* (2) *Xerophyllum tenax*

Physiographic features

This site is found in cool, moderately dry mid-elevation areas that span the lower subalpine to subalpine. It is found primarily on foot and backslope positions on lateral moraine and cirque floor landforms at elevations ranging from 1,300 to 2,600 meters (4,250-8,500 feet) on various slope inclinations ranging from 15 to 80 percent.

Figure 1.

Figure 2.

Table 2. Representative physiographic features

Landforms	(1) Mountains > Cirque headwall (2) Mountains > Glacial-valley wall (3) Mountains > Cirque floor (4) Mountains > Colluvial apron
Elevation	1,300–2,600 m
Slope	15–80%
Aspect	W, NW, N, NE, E, SE, S, SW

Climatic features

This ecological site is found in the cryic soil temperature regime and the udic soil moisture

regime. Cryic soils have average annual temperatures of less than 8 degrees C, with less than 5 degrees C difference from winter to summer. The 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 west side of the Continental Divide and has more maritime weather influences.
West Glacier Climate Station:
Mean Average Precipitation 102-229 cm 40-90 inches
Mean Average Annual Temperature -2 to 6 degrees Celsius 28-43 degrees Fahrenheit
Frost-Free Days: 30-70
Relative Effective Annual Precipitation: 76-127cm 30-50 inches
SUMMARY TABLES ARE FOR AVAILABLE CLIMATE STATIONS WHICH ARE ALL LOCATED IN VALLEYS.

Table 3. Representative climatic features

Frost-free period (characteristic range)	17-57 days
Freeze-free period (characteristic range)	76-117 days
Precipitation total (characteristic range)	508-660 mm
Frost-free period (actual range)	6-68 days
Freeze-free period (actual range)	66-127 days
Precipitation total (actual range)	508-711 mm
Frost-free period (average)	37 days
Freeze-free period (average)	97 days
Precipitation total (average)	584 mm

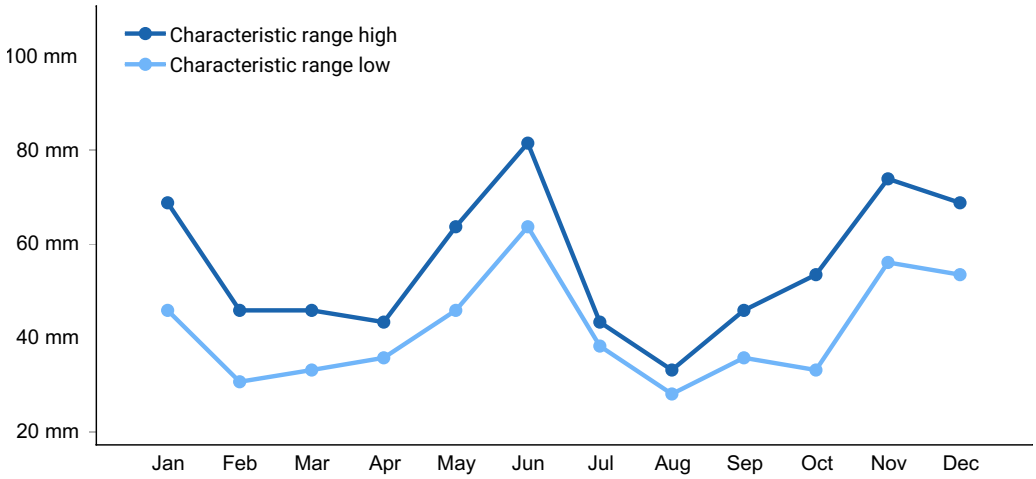


Figure 3. Monthly precipitation range

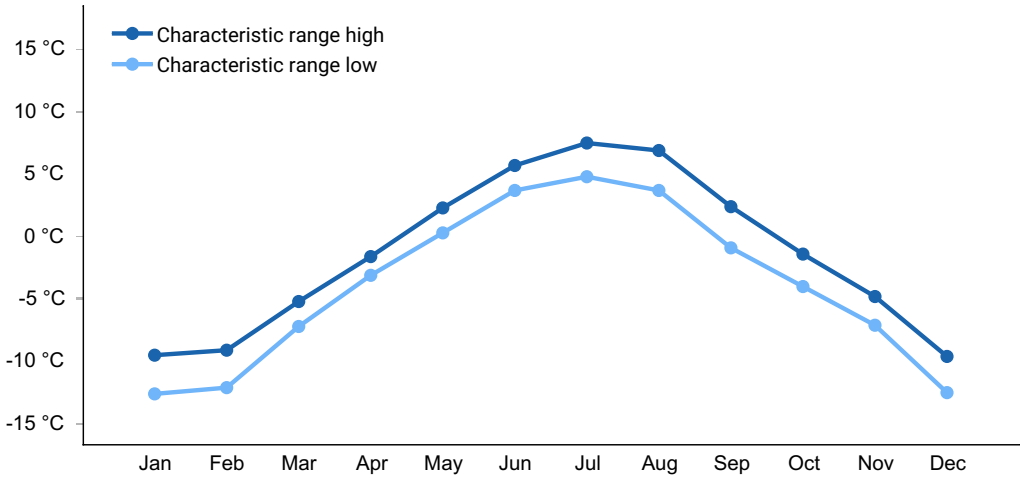


Figure 4. Monthly minimum temperature range

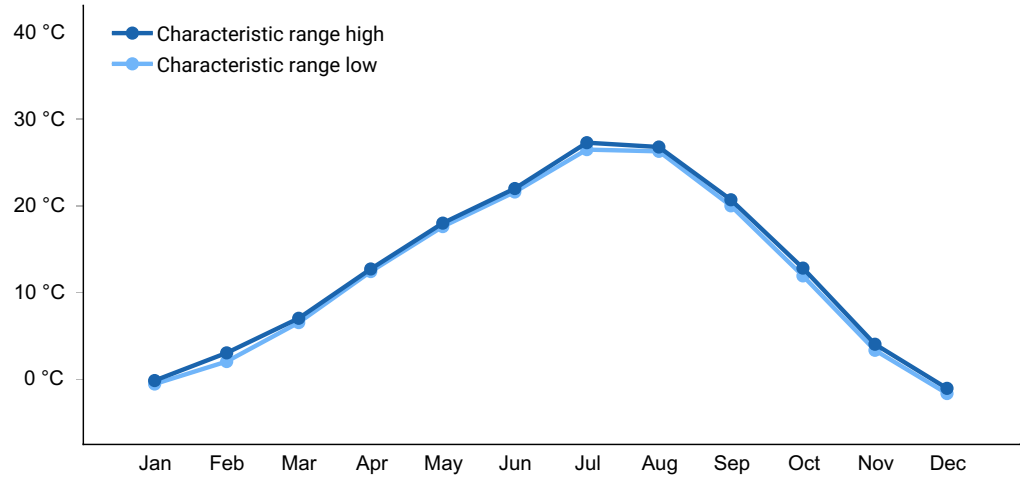


Figure 5. Monthly maximum temperature range

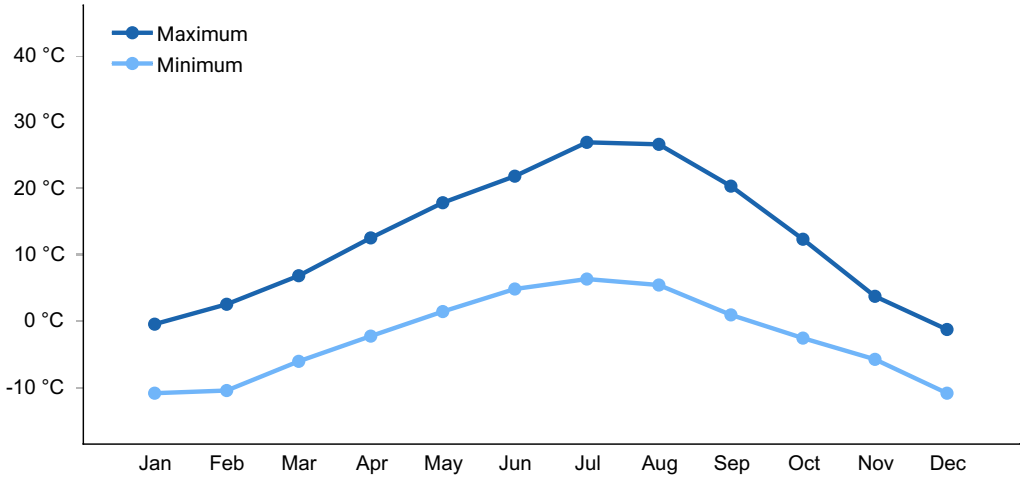


Figure 6. Monthly average minimum and maximum temperature

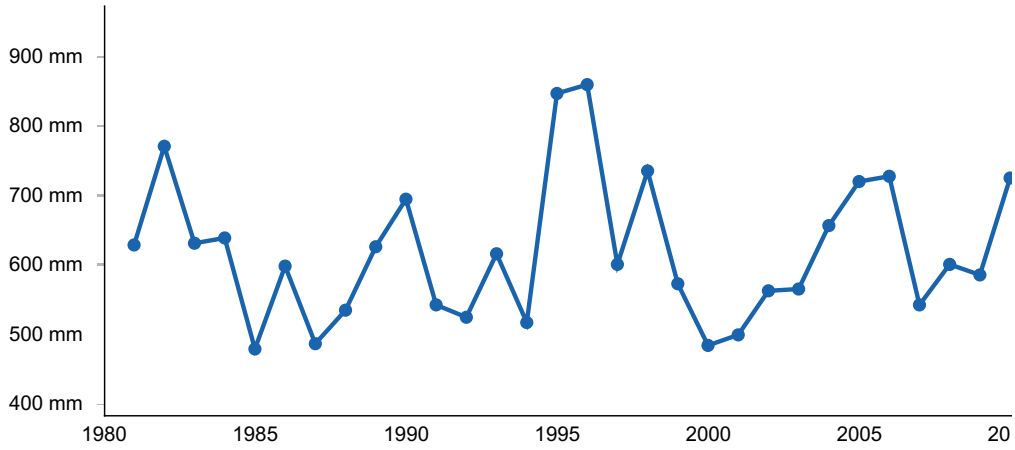


Figure 7. Annual precipitation pattern

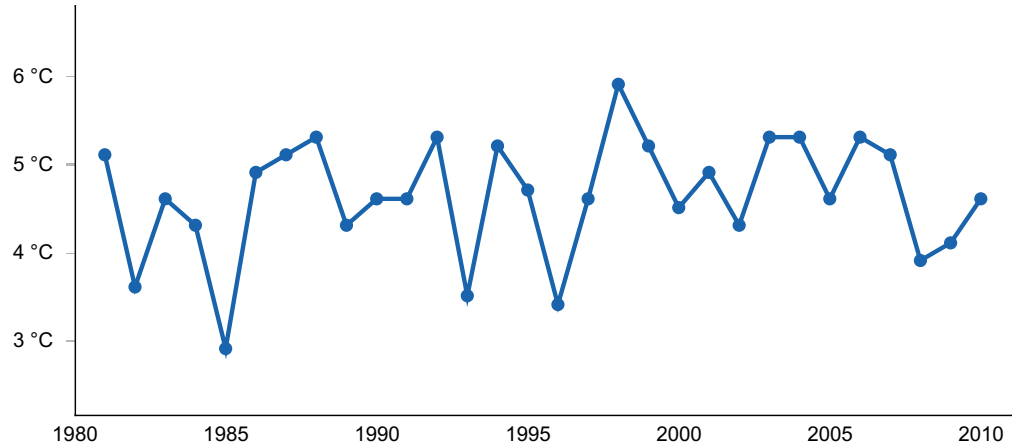


Figure 8. Annual average temperature pattern

Climate stations used

- (1) POLEBRIDGE 1 N [USC00246618], Essex, MT
- (2) POLEBRIDGE [USC00246615], Essex, MT
- (3) WEST GLACIER [USC00248809], Kalispell, MT

Influencing water features

Soil features

Representative Soil Features
Soil associated with this ecological site are very deep, well drained and formed in volcanic ash over glacial till or colluvium parent material. The origin of the volcanic ash is from the eruption of Mount Mazama (Crater Lake, Oregon) and occurs as a surface mantle on these soils. Due to the parent materials that these soils form in they generally have many rock fragments in the subsurface below the volcanic ash surface layers. These soils are classified in the Inceptisols soil order and more specifically in the Andic Haplocryepts subgroup. These soils have a volcanic ash layer with andic soil properties, a cambic diagnostic horizon and either an ochric or umbric epipedon (Soil Survey Staff, 2015).

Being under forest canopy cover these soils typically have a thin surface layer of organic material, usually less than 5 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
Bridgefore Loamy-skeletal, mixed, superactive Umbric Haplocryalfs
Risingwolf Loamy-skeletal, isotic Andic Haplocryepts

Figure 9.

Table 4. Representative soil features

Parent material	(1) Colluvium–metasedimentary rock (2) Till–metasedimentary rock (3) Volcanic ash–metasedimentary rock
Surface texture	(1) Very gravelly, ashy loam
Family particle size	(1) Loamy-skeletal
Drainage class	Well drained
Permeability class	Moderate
Soil depth	152–254 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (6.9-11.9cm)	Not specified
Soil reaction (1:1 water) (11.4-17.3cm)	Not specified

Ecological dynamics

Ecological Dynamics of the Site
This ecological site is found in cool, moderately dry mid-elevation areas, generally on moderate to steep slopes that span the lower subalpine zone. While primary data was collected in Glacier National Park (NP), this ecological site also spans into the adjacent US Forest Service (USFS) land of Flathead National Forest (FS).

Management
Various management strategies can be employed for this ecological site, depending upon the ownership of the particular land and which value is prioritized. The management of the forest determines the composition of the stand and the amount of fuel loading. A stand will be managed differently and look differently if it is managed for timber or ecological services like water quality and quantity, old growth, or endangered species. If a stand is managed for timber, it may be missing certain attributes necessary for lynx habitat. If a stand is managed for lynx habitat, it may have increased fuels and therefore an increased risk of wildfires.

The USFS Habitat Type guide states that the basal area on the west side of the Continental Divide for subalpine fir/beargrass habitat type (which relates to this ecological site) is 188+/- ft2 per acre, and the site index at 50 years for Picea is 56 feet and Abies is 47+/-6 feet. Timber production on these sites varies from low to high. Watershed management must consider the effects of southerly aspects, moderately high precipitation with high evapotranspiration, and runoff rates. Snowpack can melt periodically in the winter and disappear in spring several weeks earlier than adjacent areas. The management of USFS lands is encompassed in the “management plan” for each National Forest. The management plan for the Flathead NF also has an Appendix B that gives specific management guidelines for habitat types (which relate to our forested ecological sites) found on the forest in relation to current and historic data on forest conditions (Flathead NF Plan, 2001 and Appendix B). Another guiding USFS document is the Green et al. document (2005) which defines “Old Growth” forest for the northern Rocky Mountains. This document provides an ecologically-based classification of old growth based on forest stand attributes including numbers of large trees, snags, downed logs, structural canopy layers, canopy cover, age, and basal area. While this document finds that the bulk of the pre-settlement upland old growth in the northern Rockies was in the lower elevation, ground fire-maintained ponderosa pine/western larch/Douglas-fir types (Losensky, 1992), it does not mean that other types were not common or not important. This could apply to some of the areas of this ecological site.

The USFS Habitat Type subalpine fir/beargrass (ABLA/XETE) is common on the Flathead NF, located just west of Glacier NP. The following is a personal communication with a silvicultural forester on management of this on the Flathead NF.

Cool and Moderately Dry HTs (ABLA/XETE)

I don’t have too much experience in this habitat type. It may be too cold and dry to push western larch. Douglas fir would be a favored seral if there is no root disease. Manage lodgepole pine stands at densities to withstand mountain pine beetle populations. Even-aged management favored due to the ecology of lodgepole pine. I have seen leave islands in clearcuts (before my time) on the Tally Lake RD intended to mimic unburned areas in a stand replacement fire for wildlife cover.

State 1.0
Subalpine fir (*Abies lasiocarpa*) and, to a lesser amount, Engelmann spruce (*Picea engelmannii*), are the dominant overstory species with lodgepole pine (*Pinus contorta*) and Douglas-fir (*Pseudotsuga menziesii*) as the seral dominants with lesser amounts of western larch (*Larix occidentalis*) and western white pine (*Pinus monticola*). Whitebark pine (*Pinus albicaulis*) may be present, but these sites are not cold enough to give it a competitive advantage and therefore it is a minor component. The main understory species is the indicator species beargrass (*Xerophyllum tenax*), with the medium-sized shrub thinleaf huckleberry (*Vaccinium membranaceum*), grouse whortleberry (*Vaccinium scoparium*), and minor amounts of Oregon boxleaf (*Paxistima myrsinites*) and other understory species of pinegrass (*Calamagrostis rubescens*), Geyer’s sedge (*Carex geyeri*), broadleaf arnica (*Arnica cordifolia*), western meadow-rue (*Thalictrum occidentale*), and sidebells wintergreen (*Orthilia secunda*). This ecological site is associated to the subalpine fir/rusty menziesia ecological site on moist exposures, subalpine fir/Hitchcock’s smooth woodrush ecological site on higher elevations, and Douglas fir/thinleaf huckleberry on drier and warmer sites. Historically, this site would have had minor amounts of western white pine as a seral species before this species was decimated by the white pine blister rust epidemic (McDonald et al., 2000).

This ecological site is described as having cool and moderately dry site conditions, with a fire return interval of 50-130 years, and with fire typically of low to moderate fire intensity. This fire regime favors species such as lodgepole pine, Douglas-fir, and western larch, although subalpine fir and Engelmann spruce dominate in later successional phases. The shorter fire return interval and moderate fire intensity allow the more fire resistant Douglas-fir to be a major successional species in many stands. Douglas-fir is also able to successfully regenerate in fire-created openings where mineral soil has been exposed. Stands that are dominated by lodgepole pine and over 80 years old tend to build fuels to become a part of large stand-replacement events encompassing thousands of acres. Stand-replacement fire occurs in patches of 200 to 2,000 hectares (McDonald et al., 2000). Stand-replacement fires generally allow lodgepole pine to regenerate although some large, thick barked Douglas-fir will often survive. Stands generally have relatively large amounts of downed woody fuel, especially in those with trees over 8 cm or 3 inches in diameter. Dense understories and live fuel also help to carry fire into the tree crowns during dry conditions. Relatively deep duff layers can form and, when dry conditions exist, aid in fire spread and mortality by heating the shallow roots of subalpine fir and Engelmann spruce.

The general post-disturbance successional phases include the stand initiation phase

dominated by herbaceous and shrub species and conifer seedlings, the competitive exclusion phase of dense pole-sized mixed conifer or single seral species, the maturing forest of overstory mixed conifer trees with or without patches of regeneration and the Reference phase dominated by subalpine fir and Engelmann spruce with small gap dynamics. Underburns, which affect the understory shrub and herbaceous species and conifer regeneration the most, can occur and maintain any community phase. A stand-replacement fire in the mature forest or Reference phase would result in the stand initiation phase, with species composition of seedlings varying with site conditions and seed source. Moderate fires (or mixed severity fires) in the competitive exclusion phase would favor the more fire-resistant Douglas-fir, western larch or western white pine over lodgepole pine, Engelmann spruce, and subalpine fir. Therefore, these species would dominate the maturing forest phase for a longer period of time. After a stand-replacement fire at this stage, with serotinous lodgepole pine present, then their seedlings would dominate the seedling and competitive exclusion phases. Absence of fire will transition the competitive exclusion phase to a mature forest dominated in the overstory by a mix of conifer species. Severe fire at this stage could remove much of Douglas-fir, leaving the site to be regenerated by either serotinous lodgepole pine or remnant western larch. Severe fires that remove even western larch will return to the treeless stand initiation phase. If fire does not occur in the forest maturing phase, then this will continue into the Reference phase.

Significant fires that have occurred on the west side of the Continental Divide that affected this ecological site are the 1994 Starvation Creek fire, caused by lightning, which burned 7,202 acres in Glacier NP. The Wedge Canyon fire in 2003, which burned 30,314 acres in Glacier NP, and 53,359 total acres, was also caused by lightning. The Red Bench fire in 1988 burned 27,500 acres in Glacier NP and 36,037 total acres, and also was started by lightning. The 2003 Robert fire was caused by humans and burned 52,747 acres, 39,384 of which were in Glacier NP. The Rampage fire, caused by lightning in 2003, burned 21,630 acres in Glacier NP and the 1994 Adair fire burned 9,753 acres in Glacier NP. The Wolf Gun fire in 2003 burned 14,663 acres in Glacier NP.

Both subalpine fir and Engelmann spruce are subjected to a variety of diseases and insect pests including root rot, stem decay, bark beetles, and wood borers and defoliators. These can weaken and or kill trees, which results in small openings scattered throughout the forest, or major mortality during an outbreak such as western spruce budworm (Choristoneura occidentalis). The patterns of damage from endemic populations of insects and disease creates small openings, whereas epidemic patterns are extensive throughout the landscape. Windthrow commonly can cause additional damage to stands following disease and pest disturbance. Subalpine fir is most commonly susceptible to Armillaria and Annosus root disease, pouch, Indian paint, and red belt fungi which cause stem decay, metallic, roundheaded and western balsam bark beetle, fir canker, and defoliators such as Delphinella shoot blight, black mildew, brown felt blight, fir needlecast, snow blight, and fir-blueberry rust. Engelmann spruce is most commonly susceptible to Annosus and Schweinitzii root disease and butt rot, pini rot, stem decays by red belt fungus, metallic and roundheaded borers, spruce beetle, blue stain of sapwood, spruce broom rust, spruce

canker, and brown felt blight.

Aerial photography is a good tool to use to discern the level of insect and disease and the damage patterns and whether these are at endemic or epidemic levels. These maps capture only moments in time and infestations grow and move from location to location following their preferred habitat, so repeated photography can be necessary. Specifically for the northern region, the USFS Stand Health map (Aerial Detection Survey maps) shows that the major impact is defoliation by western spruce budworm. The defoliation was categorized as mostly low severity (equal to or less than 50 percent defoliation) and some as high severity (with greater than 50 percent defoliation) on Abies species, and the damage is contiguous or nearly continuous. The forest type was categorized as western Fir-Spruce type. There also was defoliation by western spruce budworm on Douglas-fir, but to a much lesser degree. Larch casebearer, a defoliator of western larch and generalized needlecast of western larch, also was found to a much lesser degree. Scattered small areas were found throughout the region including mortality from mountain pine beetle on lodgepole pine, Douglas-fir beetle on Douglas-fir, spruce beetle on Engelmann spruce, fir engravers and Woolly adelgid on ABIES spp., and general subalpine fir mortality. Both of these would affect this ecological site, and field notes corroborate these findings.
Community Phase 1.1
Subalpine fir (Engelmann spruce) /Utah honeysuckle/thinleaf huckleberry/beargrass-Western meadowrue.
Structure: multistory with small gap dynamics
The overstory is dominated by Subalpine fir and Engelmann spruce with small gap dynamics in which small numbers of trees are dead and conifer regeneration is infilling. The canopy cover ranges from 30-60 percent. At these higher elevations, both tree species are slow-growing and infill can take several decades, sustaining the multistory structure of this community. The presence of root rot pockets can shift the composition of this community away from its host species. The understory of this ecological site has an indicator species, beargrass, and usually this is dominant or at least co-dominant with thinleaf huckleberry. Species that have high frequency and canopy cover include: beargrass, thinleaf huckleberry, fireweed, Utah honeysuckle and western meadowrue (7 sites canopy cover data). Foliar cover at two sites of this ecological site is high (59%), and soil surface is predominantly duff (53.5%) and moss (44%). This is a multi-storied forested ecological site with trees ranging 7-18 m (23-60 feet) tall, a tall shrub layer approximately 102cm (40 inches) tall including Sitka alder, Utah honeysuckle, a lower layer 38-51 cm or 15-20 inches tall including beargrass and thinleaf huckleberry and the lower layer of diverse forbs less than 15 cm or 6 inches tall. The understory of this community has the medium-statured thinleaf huckleberry and a variety of other shrubs in clumps. This ecological site must have a presence of beargrass and sometimes this is dominant. At this phase Armillaria root rot and defoliation by western spruce budworm can be a threat.

Community Phase Pathway 1.1A
This pathway represents a larger disturbance: an insect infestation, wind storm, or rot pocket would create this forest structure. Areas of regeneration would range from

approximately 2 to 5 acres.

Community Phase Pathway 1.1B
This pathway represents a major stand-replacement disturbance such as a high-intensity fire, large-scale wind event, or major insect infestation.
Community Phase 1.2:
Subalpine fir-Engelmann spruce-Douglas-fir/Utah honeysuckle/thinleaf huckleberry/white spirea-Oregon boxleaf/beargrass
Structure: mosaic of mature overstory and regenerating openings
Community Phase 1.2 retains some areas that resemble Community Phase 1.1, but also contains moderate-sized (2-5 acres) openings. Subalpine fir and Engelmann spruce are both host to organisms causing root rot and heart rot, and along with windthrow these can cause large pockets of overstory mortality. These areas may take decades to become reforested, resulting in either patches of shrubs or seral species such as western larch and Douglas-fir. As the organisms slowly die off due to a lack of host trees, subalpine fir and Engelmann spruce will re-colonize these areas. This community can be prone to Armillaria root rot and western spruce budworm on fir.

Community Phase Pathway 1.2A
This pathway represents growth over time with no further significant disturbance. The areas of regeneration pass through the typical stand phases—competitive exclusion, maturation, and understory reinitiating—until they resemble the old-growth structure of the Reference Community.

Community Phase Pathway 1.2B
This pathway represents a major stand-replacement fire disturbance, such as a major insect outbreak, or major fire event, which leads to the stand initiation phase of forest development.

Community Phase 1.3:
Structure: patchy clumps of regeneration, single story
Community Phase 1.3 is a forest in the stand initiation phase, possibly with scattered remnant mature trees; the composition of the seedlings depends upon the natural seed sources available. The canopy cover generally is less than 10 percent as a mixture of conifers including Douglas-fir, lodgepole pine, western larch, Engelmann spruce, and subalpine fir. If serotinous lodgepole seedbank is present, then this species will dominate the area.

Community Phase Pathway 1.3A
This pathway represents continued growth over time with no further major disturbance.

Community Phase 1.4: *Pinus contorta* (Subalpine fir-Engelmann spruce-Douglas-fir)/thinleaf huckleberry/grouse whortleberry-white spirea/beargrass
Structure: dense single story

Community Phase1.4 is a forest in the competitive exclusion phase, possibly with scattered remnant mature trees. Individual trees compete for the available water and nutrients. The canopy cover ranges from 50-80 percent. Canopy closure is very high within the areas successfully reforested, leading eventually to a diminished graminoid community, but also providing protection for those species which do well in the shade, such as prince's pine. This community is more tolerant of Armillaria root rot due to forest stand composition, but is vulnerable to defoliation by western spruce budworm on fir. The understory at this community phase of this ecological site, generally has a shrub component usually dominated by either thinleaf huckleberry, grouse whortleberry or white spirea (9 sites of canopy cover data). Beargrass is always present and may be dominant. Species with the highest frequency include heartleaf arnica, prince's plume, white spirea and beargrass.

Community Phase Pathway 1.4A

This pathway represents continued growth over time with no further major disturbance.

Community Phase Pathway 1.4B

This pathway represents a major stand-replacement disturbance, such as a major insect outbreak or major fire event, which leads to the stand initiation phase of forest development.

Community Phase 1.5: Subalpine fir-Engelmann spruce-Douglas-fir/Utah honeysuckle/thinleaf huckleberry/white spirea-Oregon boxleaf/beargrass

Structure: single story with few small openings

Community Phase 1.5 is a maturing forest which is starting to differentiate vertically. The canopy cover ranges from 40-60 percent and includes subalpine fir, Engelmann spruce, and Douglas fir in the overstory. The understory has clumps of thinleaf huckleberry, Oregon boxleaf shrub and beargrass. Individual trees are dying due to insects, disease, competition, or windthrow, allowing some sunlight to reach the forest floor. This allows for an increase in the understory as well as some pockets of overstory tree species regeneration. This community is prone to Armillaria root rot and western spruce budworm on fir. This ecological site has an indicator species, beargrass, and this can be dominant in the understory with a shrub component of thinleaf huckleberry, grouse whortleberry, white spirea and the tall shrubs Utah honeysuckle, Scouler's willow, Rocky mountain maple. Species with the highest frequency include: prince's plume, western rattlesnake plantain, white spirea, thinleaf huckleberry and beargrass (canopy cover data 13 sites).

Community Phase Pathway 1.5A

This pathway represents no further major disturbance. Continued growth over time, as well as ongoing mortality, leads to continued vertical diversification. The community begins to resemble the structure of the Reference Community, with small pockets of regeneration and a more diversified understory.

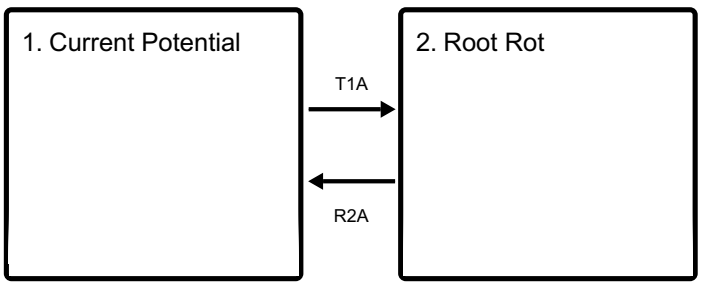
Community Phase Pathway 1.5B

This pathway represents a major stand-replacement fire disturbance leading to the stand initiation phase of forest development.

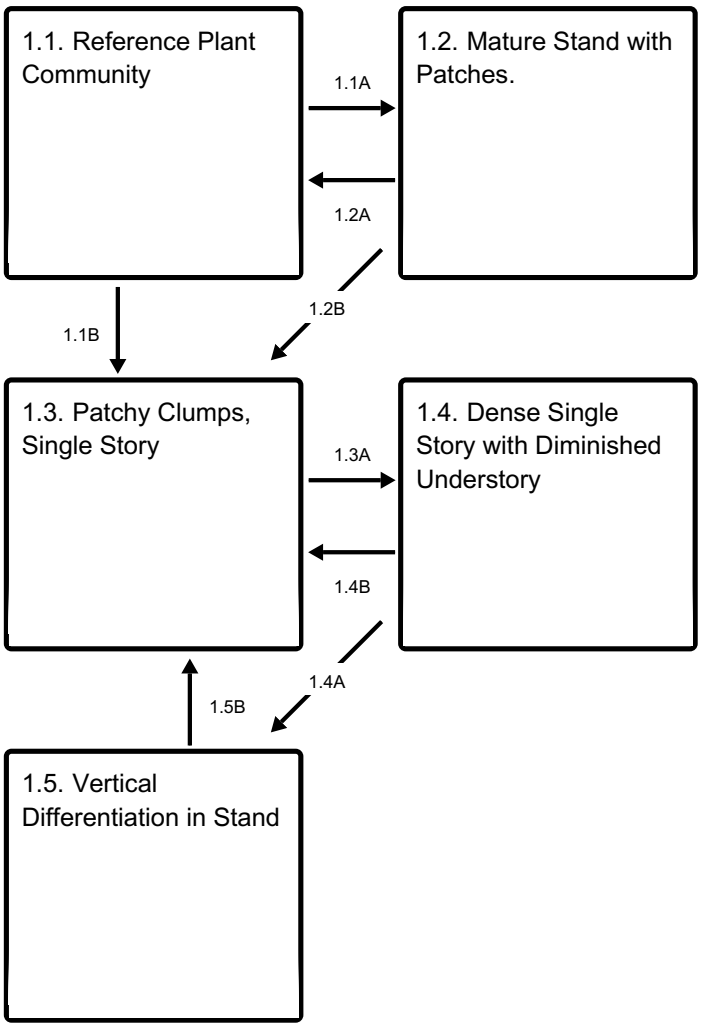
State 2.0
Another disease affecting this ecological site is root rot. Armillaria root disease is the most common root disease fungus in this region, especially prevalent west of the Continental Divide. It may be difficult to detect until it has killed enough trees to create large root disease pockets or centers, ranging in size from a fraction of an acre to hundreds of acres. The root disease spreads from an affected tree to its surrounding neighbors through root contact. The root disease affects the most susceptible tree species first, leaving less susceptible tree species that mask its presence. When root rot is severe, the pocket has abundant regeneration or dense brush growth in the center. In western Montana and northern Idaho, Armillaria is present in most stands with diffuse mortality and large and small root disease centers. The disease pattern is one of multiple clones merging to form essentially continuous coverage of sites. Grouped as well as dispersed mortality can occur throughout the stand. A mosaic of brushy openings, patches of dying trees, and apparently unaffected trees may cover large areas. There can be highly significant losses, usually requiring species conversion in the active management approach. Management tactics include identify the type of Armillaria root disease present, and manage for pines and larch. Pre-commercial thinning may improve growth and survival of pines and larch. Avoid harvests that leave susceptible species (usually Douglas-fir or true firs) as crop trees (Hagle, 2010). A link has been determined between parent material and susceptibility to root disease, and metasedimentary parent material is thought to increase the risk of root disease. Glacier NP is dominated by metasedimentary parent material and may be more at risk than other areas to root disease (Kimsey et al., 2012). If a stand sustains very high levels of roots disease mortality, then a coniferous stand could cross a threshold and become a shrubland, once all conifers are gone (Kimsey et al., 2012).

State and transition model

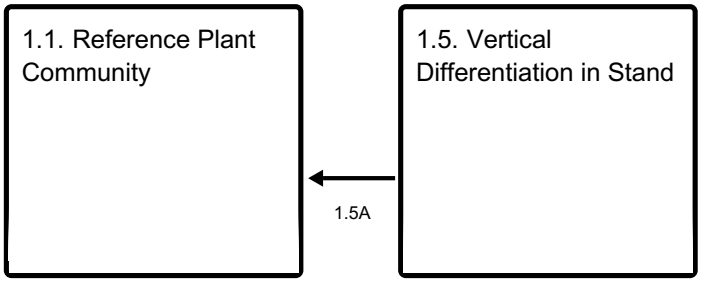
Ecosystem states



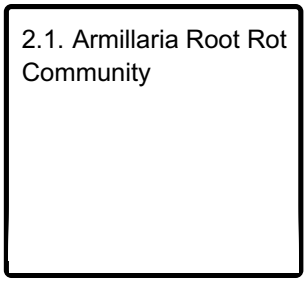
State 1 submodel, plant communities



Communities 1 and 5 (additional pathways)



State 2 submodel, plant communities



State 1
Current Potential

Subalpine fir (*Abies lasiocarpa*) and, to a lesser amount, Engelmann spruce (*Picea*

engelmannii), are the dominant overstory species with lodgepole pine (*Pinus contorta*) and Douglas-fir (*Pseudotsuga menziesii*) as the seral dominants with lesser amounts of western larch (*Larix occidentalis*) and western white pine (*Pinus monticola*). Whitebark pine (*Pinus albicaulis*) may be present, but these sites are not cold enough to give it a competitive advantage and therefore it is a minor component. The main understory species is the indicator species beargrass (*Xerophyllum tenax*), with the medium-sized shrub thinleaf huckleberry (*Vaccinium membranaceum*), grouse whortleberry (*Vaccinium scoparium*), and minor amounts of Oregon boxleaf (*Paxistima myrsinites*) and other understory species of pinegrass (*Calamagrostis rubescens*), Geyer's sedge (*Carex geyeri*), broadleaf arnica (*Arnica cordifolia*), western meadow-rue (*Thalictrum occidentale*), and sidebells wintergreen (*Orthilia secunda*). This ecological site is associated to the subalpine fir/rusty menziesia ecological site on moist exposures, subalpine fir/Hitchcock's smooth woodrush ecological site on higher elevations, and Douglas fir/thinleaf huckleberry on drier and warmer sites. Historically, this site would have had minor amounts of western white pine as a seral species before this species was decimated by the white pine blister rust epidemic (McDonald et al., 2000). This ecological site is described as having cool and moderately dry site conditions, with a fire return interval of 50-130 years, and with fire typically of low to moderate fire intensity. This fire regime favors species such as lodgepole pine, Douglas-fir, and western larch, although subalpine fir and Engelmann spruce dominate in later successional phases. The shorter fire return interval and moderate fire intensity allow the more fire resistant Douglas-fir to be a major successional species in many stands. Douglas-fir is also able to successfully regenerate in fire-created openings where mineral soil has been exposed. Stands that are dominated by lodgepole pine and over 80 years old tend to build fuels to become a part of large stand-replacement events encompassing thousands of acres. Stand-replacement fire occurs in patches of 200 to 2,000 hectares (McDonald et al., 2000). Stand-replacement fires generally allow lodgepole pine to regenerate although some large, thick barked Douglas-fir will often survive. Stands generally have relatively large amounts of downed woody fuel, especially in those with trees over 8 cm or 3 inches in diameter. Dense understories and live fuel also help to carry fire into the tree crowns during dry conditions. Relatively deep duff layers can form and, when dry conditions exist, aid in fire spread and mortality by heating the shallow roots of subalpine fir and Engelmann spruce. The general post-disturbance successional phases include the stand initiation phase dominated by herbaceous and shrub species and conifer seedlings, the competitive exclusion phase of dense pole-sized mixed conifer or single seral species, the maturing forest of overstory mixed conifer trees with or without patches of regeneration and the Reference phase dominated by subalpine fir and Engelmann spruce with small gap dynamics. Underburns, which affect the understory shrub and herbaceous species and conifer regeneration the most, can occur and maintain any community phase. A stand-replacement fire in the mature forest or Reference phase would result in the stand initiation phase, with species composition of seedlings varying with site conditions and seed source. Moderate fires (or mixed severity fires) in the competitive exclusion phase would favor the more fire-resistant Douglas-fir, western larch or western white pine over lodgepole pine, Engelmann spruce, and subalpine fir. Therefore, these species would dominate the maturing forest phase for a longer period of time. After a stand-replacement

fire at this stage, with serotinous lodgepole pine present, then their seedlings would dominate the seedling and competitive exclusion phases. Absence of fire will transition the competitive exclusion phase to a mature forest dominated in the overstory by a mix of conifer species. Severe fire at this stage could remove much of Douglas-fir, leaving the site to be regenerated by either serotinous lodgepole pine or remnant western larch. Severe fires that remove even western larch will return to the treeless stand initiation phase. If fire does not occur in the forest maturing phase, then this will continue into the Reference phase. Significant fires that have occurred on the west side of the Continental Divide that affected this ecological site are the 1994 Starvation Creek fire, caused by lightning, which burned 7,202 acres in Glacier NP. The Wedge Canyon fire in 2003, which burned 30,314 acres in Glacier NP, and 53,359 total acres, was also caused by lightning. The Red Bench fire in 1988 burned 27,500 acres in Glacier NP and 36,037 total acres, and also was started by lightning. The 2003 Robert fire was caused by humans and burned 52,747 acres, 39,384 of which were in Glacier NP. The Rampage fire, caused by lightning in 2003, burned 21,630 acres in Glacier NP and the 1994 Adair fire burned 9,753 acres in Glacier NP. The Wolf Gun fire in 2003 burned 14,663 acres in Glacier NP. Both subalpine fir and Engelmann spruce are subjected to a variety of diseases and insect pests including root rot, stem decay, bark beetles, and wood borers and defoliators. These can weaken and or kill trees, which results in small openings scattered throughout the forest, or major mortality during an outbreak such as western spruce budworm (Choristoneura occidentalis). The patterns of damage from endemic populations of insects and disease creates small openings, whereas epidemic patterns are extensive throughout the landscape. Windthrow commonly can cause additional damage to stands following disease and pest disturbance. Subalpine fir is most commonly susceptible to Armillaria and Annosus root disease, pouch, Indian paint, and red belt fungi which cause stem decay, metallic, roundheaded and western balsam bark beetle, fir canker, and defoliators such as Delphinella shoot blight, black mildew, brown felt blight, fir needlecast, snow blight, and fir-blueberry rust. Engelmann spruce is most commonly susceptible to Annosus and Schweinitzii root disease and butt rot, pini rot, stem decays by red belt fungus, metallic and roundheaded borers, spruce beetle, blue stain of sapwood, spruce broom rust, spruce canker, and brown felt blight. Aerial photography is a good tool to use to discern the level of insect and disease and the damage patterns and whether these are at endemic or epidemic levels. These maps capture only moments in time and infestations grow and move from location to location following their preferred habitat, so repeated photography can be necessary. Specifically for the northern region, the USFS Stand Health map (Aerial Detection Survey maps) shows that the major impact is defoliation by western spruce budworm. The defoliation was categorized as mostly low severity (equal to or less than 50 percent defoliation) and some as high severity (with greater than 50 percent defoliation) on Abies species, and the damage is contiguous or nearly continuous. The forest type was categorized as western Fir-Spruce type. There also was defoliation by western spruce budworm on Douglas-fir, but to a much lesser degree. Larch casebearer, a defoliator of western larch and generalized needlecast of western larch, also was found to a much lesser degree. Scattered small areas were found throughout the region including mortality from mountain pine beetle on lodgepole pine, Douglas-fir beetle on Douglas-fir, spruce beetle on Engelmann spruce, fir engravers and Woolly adelgid on ABIES spp., and

general subalpine fir mortality. Both of these would affect this ecological site, and field notes corroborate these findings.

Community 1.1
Reference Plant Community

Plant Community 1.1 Reference Community Subalpine fir (Engelmann spruce)/Utah honeysuckle/thinleaf huckleberry/beargrass-Western meadowrue. Structure: Multistory with small gap dynamics Tree Age: 150+ years

Forest overstory. The forest overstory composition is dominated by subalpine fir and is predominantly a multi-storied stand of tall, large, mature trees. There are some emergent subalpine fir and western larch above the main canopy and the sub-canopy is composed of subalpine fir and Engelmann spruce in very low cover.

Forest understory. The understory composition is predominantly moderate to tall statured shrubs including Utah honeysuckle, thinleaf huckleberry and white spirea. Beneath the shrubs the herbaceous layer can frequently be dominated by beargrass or

occur in a mixture with western meadowrue, fireweed, leafybract aster and Geyer's sedge.

Dominant plant species

- subalpine fir (*Abies lasiocarpa*), tree
- Utah honeysuckle (*Lonicera utahensis*), shrub
- thinleaf huckleberry (*Vaccinium membranaceum*), shrub
- common beargrass (*Xerophyllum tenax*), other herbaceous
- western meadow-rue (*Thalictrum occidentale*), other herbaceous
- fireweed (*Chamerion angustifolium*), other herbaceous
- Geyer's sedge (*Carex geyeri*), other herbaceous

Table 5. Soil surface cover

Tree basal cover	0-10%
Shrub/vine/liana basal cover	0-10%
Grass/grasslike basal cover	0-2%
Forb basal cover	0-10%
Non-vascular plants	0-5%
Biological crusts	0%
Litter	60-80%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 6. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0-2%	5-10%	0-2%	5-10%
>0.15 <= 0.3	0-5%	5-10%	0-2%	5-10%
>0.3 <= 0.6	0-5%	10-15%	–	10-20%
>0.6 <= 1.4	0-5%	10-15%	–	–
>1.4 <= 4	0-5%	0-5%	–	–
>4 <= 12	0-5%	0-5%	–	–
>12 <= 24	10-30%	–	–	–
>24 <= 37	10-30%	–	–	–
>37	2-10%	–	–	–

Community 1.2
Mature Stand with Patches.

Plant Community 1.2 Subalpine fir-Engelmann spruce-Douglas fir/Utah honeysuckle/Thinleaf huckleberry/white spirea-Oregon boxleaf/beargrass. Sturcture: Mature stand with patches. Tree Age: 0-10 and 150+ years.

Community 1.3
Patchy Clumps, Single Story

Plant Community 1.3 Structure: patchy clumps, single story. Time spent in this phase: 20-40 years.

Community 1.4
Dense Single Story with Diminished Understory

Plant Community 1.4 *Pinus contorta*(Subalpine fir-Engelmann spruce-Douglas fir)/ thinleaf huckleberry/grouse whortleberry-white spirea/Beargrass. Structure: dense single story with diminished understory. Time spent in this phase: 25-60 years

Forest overstory. The forest overstory composition is dominated in both the main canopy and the sub-canopy by lodgepole pine. There are other tree species in very low cover that include subalpine fir, Engelmann spruce and Douglas fir.

Forest understory. The forest understory is composed of tall herbaceous species such as beargrass and some medium and shorter shrubs including thinleaf huckleberry, grouse whortleberry, white spriea.

Dominant plant species

- lodgepole pine (*Pinus contorta*), tree
- thinleaf huckleberry (*Vaccinium membranaceum*), shrub
- grouse whortleberry (*Vaccinium scoparium*), shrub
- white spirea (*Spiraea betulifolia*), shrub
- common beargrass (*Xerophyllum tenax*), other herbaceous
- heartleaf arnica (*Arnica cordifolia*), other herbaceous
- pinegrass (*Calamagrostis rubescens*), other herbaceous
- lupine (*Lupinus*), other herbaceous
- sidebells wintergreen (*Orthilia secunda*), other herbaceous
- western meadow-rue (*Thalictrum occidentale*), other herbaceous

Table 7. Soil surface cover

Tree basal cover	0-15%
Shrub/vine/liana basal cover	0-10%
Grass/grasslike basal cover	0-2%
Forb basal cover	0-10%
Non-vascular plants	0-5%
Biological crusts	0%
Litter	60-80%
Surface fragments >0.25" and <=3"	0-5%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-5%

Table 8. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0-5%	0-10%	0-2%	5-10%
>0.15 <= 0.3	0-5%	0-10%	0-2%	5-10%
>0.3 <= 0.6	0-5%	5-10%	–	0-10%
>0.6 <= 1.4	0-5%	0-10%	–	–
>1.4 <= 4	0-10%	–	–	–
>4 <= 12	0-10%	–	–	–
>12 <= 24	20-40%	–	–	–
>24 <= 37	10-30%	–	–	–
>37	0-5%	–	–	–

Community 1.5
Vertical Differentiation in Stand

Plant Community 1.5 Subalpine fir-Engelmann spruce-Douglas fir/Utah honeysuckle/Thinleaf huckleberry/ white spirea-Oregon boxleaf/beargrass. Structure: some vertical differentiation in stand. Time spent in this phase: 20-50 years.

Forest overstory. The forest overstory is composed primarily of subalpine fir in the main canopy. Lesser amounts of seral tree species exist including lodgepole pine, Douglas fir and Engelmann spruce. In higher elevations, this ecological site may also have very low cover of whitebark pine. The main canopy is multi-storied but there are some emergent trees above the main canopy.

Forest understory. The forest understory is composed equally of shrub species and herbaceous forbs, namely the moderate stature beargrass. The shrubs are predominantly in moderate to low stature layers and include Utah honeysuckle, thinleaf huckleberry, white spirea and Oregon boxwood. Within the lower layer of shrubs, the forb beargrass can be dominant or mixed with other herbaceous species including prince's plume, western rattlesnake plantain and Geyer's sedge.

Dominant plant species

- subalpine fir (*Abies lasiocarpa*), tree
- Engelmann spruce (*Picea engelmannii*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- Utah honeysuckle (*Lonicera utahensis*), shrub
- thinleaf huckleberry (*Vaccinium membranaceum*), shrub
- white spirea (*Spiraea betulifolia*), shrub
- Oregon boxleaf (*Paxistima myrsinites*), shrub
- common beargrass (*Xerophyllum tenax*), other herbaceous

Table 9. Soil surface cover

Tree basal cover	5-10%
Shrub/vine/liana basal cover	5-10%
Grass/grasslike basal cover	0-2%
Forb basal cover	5-10%
Non-vascular plants	0-5%
Biological crusts	0%
Litter	50-70%
Surface fragments >0.25" and <=3"	0-2%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 10. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0-5%	5-20%	–	5-10%
>0.15 <= 0.3	0-5%	5-20%	–	5-20%
>0.3 <= 0.6	0-5%	10-20%	–	5-20%
>0.6 <= 1.4	0-5%	10-20%	–	–
>1.4 <= 4	0-5%	1-5%	–	–
>4 <= 12	5-10%	1-5%	–	–
>12 <= 24	10-30%	–	–	–
>24 <= 37	10-30%	–	–	–
>37	5-10%	–	–	–

Pathway 1.1A
Community 1.1 to 1.2

This pathway represents a larger disturbance: an insect infestation, wind storm, or rot pocket would create this forest structure. Areas of regeneration would range from approximately 2 to 5 acres.

Pathway 1.1B

Community 1.1 to 1.3

This pathway represents a major stand-replacement disturbance such as a high-intensity fire, large-scale wind event, or major insect infestation.

Pathway 1.2A
Community 1.2 to 1.1

This pathway represents growth over time with no further significant disturbance. The areas of regeneration pass through the typical stand phases—competitive exclusion, maturation, and understory reinitiating—until they resemble the old-growth structure of the Reference Community.

Pathway 1.2B
Community 1.2 to 1.3

This pathway represents a major stand-replacement fire disturbance, such as a major insect outbreak, or major fire event, which leads to the stand initiation phase of forest development.

Pathway 1.3A
Community 1.3 to 1.4

This pathway represents continued growth over time with no further major disturbance.

Pathway 1.4B
Community 1.4 to 1.3

This pathway represents a major stand-replacement disturbance, such as a major insect outbreak or major fire event, which leads to the stand initiation phase of forest development.

Pathway 1.4A
Community 1.4 to 1.5

This pathway represents continued growth over time with no further major disturbance.

Pathway 1.5A
Community 1.5 to 1.1

This pathway represents no further major disturbance. Continued growth over time, as well as ongoing mortality, leads to continued vertical diversification. The community begins to resemble the structure of the Reference Community, with small pockets of regeneration and a more diversified understory.

Pathway 1.5B
Community 1.5 to 1.3

This pathway represents a major stand-replacement fire disturbance leading to the stand initiation phase of forest development.

State 2
Root Rot

Another disease affecting this ecological site is root rot. Armillaria root disease is the most common root disease fungus in this region, especially prevalent west of the Continental Divide. It may be difficult to detect until it has killed enough trees to create large root disease pockets or centers, ranging in size from a fraction of an acre to hundreds of acres. The root disease spreads from an affected tree to its surrounding neighbors through root contact. The root disease affects the most susceptible tree species first, leaving less susceptible tree species that mask its presence. When root rot is severe, the pocket has abundant regeneration or dense brush growth in the center. In western Montana and northern Idaho, Armillaria is present in most stands with diffuse mortality and large and small root disease centers. The disease pattern is one of multiple clones merging to form essentially continuous coverage of sites. Grouped as well as dispersed mortality can occur throughout the stand. A mosaic of brushy openings, patches of dying trees, and apparently unaffected trees may cover large areas. There can be highly significant losses, usually requiring species conversion in the active management approach. Management tactics include identify the type of Armillaria root disease present, and manage for pines and larch. Pre-commercial thinning may improve growth and survival of pines and larch. Avoid harvests that leave susceptible species (usually Douglas-fir or true firs) as crop trees (Hagle, 2010). A link has been determined between parent material and susceptibility to root disease, and metasedimentary parent material is thought to increase the risk of root disease. Glacier NP is dominated by metasedimentary parent material and may be more at risk than other areas to root disease (Kimsey et al., 2012). If a stand sustains very high levels of roots disease mortality, then a coniferous stand could cross a threshold and become a shrubland, once all conifers are gone (Kimsey et al., 2012).

Community 2.1
Armillaria Root Rot Community

Metasedimentary and quartzite parent material (vitrandic soils on south and west aspects). Shrubland with no trees Time=50 years

Transition T1A
State 1 to 2

High density fir becomes infected

Restoration pathway R2A
State 2 to 1

Active management and seeding of true pine and larch species.

Additional community tables

Table 11. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Forb					
1	**Perennial and annual forbs**			–	
	common beargrass	XETE	*Xerophyllum tenax*	–	0–70
	western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	0–5
Shrub/Vine					
2	**Shrubs and subshrubs**			–	
	thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	0–40
	pipsissewa	CHUM	*Chimaphila umbellata*	–	0–20
	Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	0–5
	grouse whortleberry	VASC	*Vaccinium scoparium*	–	0–5
	twinberry honeysuckle	LOIN5	*Lonicera involucrata*	–	0–5
	Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	0–5

Table 12. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
subalpine fir	ABLA	*Abies lasiocarpa*	Native	15.2–36.6	15–40	38.1–114.3	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	–	0–5	–	–
Douglas-fir	PSME	*Pseudotsuga menziesii*	Native	–	0–5	–	–
whitebark pine	PIAL	*Pinus albicaulis*	Native	–	0–3	–	–

Table 13. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0.5–37.5
pinegrass	CARU	*Calamagrostis rubescens*	–	–	3
Forb/Herb					
common beargrass	XETE	*Xerophyllum tenax*	–	–	3–62.5
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	3–15
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–15
wintergreen	PYROL	*Pyrola*	–	–	15
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	3
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5–3
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	3
arnica	ARNIC	*Arnica*	–	–	3
Sitka valerian	VASI	*Valeriana sitchensis*	–	–	0.5–3
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5–3
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	0.5–3
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	0.5
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0.5
western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	0.5
onion	ALLIU	*Allium*			0.5

onion	ALLIU	*Allium*	–	–	0.5
Shrub/Subshrub					
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	3–37.5
white spirea	SPBE2	*Spiraea betulifolia*	–	–	3–15
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	3–15
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	3
prickly currant	RILA	*Ribes lacustre*	–	–	3
sticky currant	RIVI3	*Ribes viscosissimum*	–	–	3
thimbleberry	RUPA	*Rubus parviflorus*	–	–	3
common snowberry	SYAL	*Symphoricarpos albus*	–	–	3
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–3
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	3
red elderberry	SARA2	*Sambucus racemosa*	–	–	0.5
Nonvascular					
Moss	2MOSS	*Moss*	–	–	3

Table 14. Community 1.4 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
lodgepole pine	PICO	*Pinus contorta*	Native	15.2–30.5	38–85	38.1–88.9	–
lodgepole pine	PICO	*Pinus contorta*	Native	9.1–15.2	5–65	38.1–63.5	–
subalpine fir	ABLA	*Abies lasiocarpa*	Native	9.1–30.5	1–10	38.1–88.9	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	9.1–30.5	0–5	38.1–88.9	–
Douglas-fir	PSME	*Pseudotsuga menziesii*	Native	9.1–30.5	0–5	38.1–88.9	–

Table 15. Community 1.4 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
pinegrass	CARU	*Calamagrostis rubescens*	–	–	0.5–15
Geyer's sedge	CAGE2	*Carex geyeri*			0.5–5

Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0.5–3
mountain brome	BRMA4	*Bromus marginatus*	–	–	0.5
Forb/Herb					
common beargrass	XETE	*Xerophyllum tenax*	–	–	3–62.5
green false hellebore	VEVI	*Veratrum viride*	–	–	3
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–3
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	3
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–3
angelica	ANGEL	*Angelica*	–	–	3
western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	3
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	0.5–3
fireweed	CHAN9	*Chamerion angustifolium*	–	–	3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3
western showy aster	EUCO36	*Eurybia conspicua*	–	–	0.5–3
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	3
geranium	GERAN	*Geranium*	–	–	3
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0.5–3
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5–3
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	0.5
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5
northwestern twayblade	LICA10	*Listera caurina*	–	–	0.5
lupine	LUPIN	*Lupinus*	–	–	0.5
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	0.5
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
summer coralroot	COMA25	*Corallorhiza maculata*	–	–	0.5
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	0.5
Fern/fern ally					
common ladyfern	ATFI	*Athyrium filix-femina*	–	–	3
Shrub/Subshrub					

thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	3–37.5
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	3–37.5
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	3–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	3–15
common snowberry	SYAL	*Symphoricarpos albus*	–	–	3
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–3
creeping barberry	MARE11	*Mahonia repens*	–	–	3
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–3
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	3
prickly currant	RILA	*Ribes lacustre*	–	–	0.5
rose	ROSA5	*Rosa*	–	–	0.5
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0.5
whortleberry	VAMY2	*Vaccinium myrtillus*	–	–	0.5
Nonvascular					
Moss	2MOSS	*Moss*	–	–	3

Table 16. Community 1.5 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
subalpine fir	ABLA	*Abies lasiocarpa*	Native	15.2–30.5	20–60	38.1–114.3	–
lodgepole pine	PICO	*Pinus contorta*	Native	15.2–30.5	15–38	38.1–88.9	–
Douglas-fir	PSME	*Pseudotsuga menziesii*	Native	15.2–30.5	5–38	38.1–114.3	–
subalpine fir	ABLA	*Abies lasiocarpa*	Native	9.1–15.2	5–20	38.1–88.9	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	15.2–30.5	3–15	38.1–101.6	–

Table 17. Community 1.5 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0.5–15

pinegrass	CARU	*Calamagrostis rubescens*	–	–	3
Forb/Herb					
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3
broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	3
western showy aster	EUCO36	*Eurybia conspicua*	–	–	3
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5–3
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	3
bracted lousewort	PEBR	*Pedicularis bracteosa*	–	–	0.5–3
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5–3
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	3
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5
liverleaf wintergreen	PYAS	*Pyrola asarifolia*	–	–	0.5
greenflowered wintergreen	PYCH	*Pyrola chlorantha*	–	–	0.5
common yarrow	ACMI2	*Achillea millefolium*	–	–	0.5
western blue virginsbower	CLOC2	*Clematis occidentalis*	–	–	0.5
Shrub/Subshrub					
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	3–37.5
common beargrass	XETE	*Xerophyllum tenax*	–	–	3–37.5
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	3–15
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	3–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	3–15
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–15
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	0.5–3
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	3
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	3
common snowberry	SYAL	*Symphoricarpos albus*	–	–	3
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	3
rose	ROSA5	*Rosa*	–	–	3

darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–3
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0.5
russet buffaloberry	SHCA	*Shepherdia canadensis*	–	–	0.5
creeping barberry	MARE11	*Mahonia repens*	–	–	0.5
Tree					
Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	15
Nonvascular					
Moss	2MOSS	*Moss*	–	–	3–37.5

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Approval

Kirt Walstad, 3/11/2025

Rangeland health reference sheet

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

Author(s)/participant(s)	
Contact for lead author	
Date	12/18/2020
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:**
