USDA Natural Resources
Conservation Service

Ecological site F043AX958MT
Alpine Krummholtz Coniferous subalpine fir-whitebark pine/grouse whortleberry Abies lasciocarpa-Pinus albicaulis (Picea engelmannii)/Vaccinium scoparium

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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/LUGLH. This site relates to the USFS Habitat Type Group 11 and Fire Group 10. Both of these classification guides are specifically for the western Montana and northern Idaho region. It also relates to the National Park Service vegetation map, NatureServe classification *Pinus albicaulis*-Abies lasiocarpa Woodland CEGL000128 and *Xerophyllum tenax* Herbaceous Vegetation (CEGL005859).

Ecological site concept

Ecological Site Concept
The 43A alpine krummholtz coniferous site is found along the Continental Divide in the severe, cold, high elevations of the upper subalpine/alpine and timberline zones. The dominant landform is cirque headwalls, on backslope positions, at elevations ranging from 1,600 to 2,700 meters (5,250-8,850 feet). This site occurs on all aspects and generally on steeper slopes ranging from 15 to 80 percent. This timberline ecological site begins above the cold limits of certain subalpine species including: Douglas fir, grand fir, western white pine, lodgepole pine, and western larch. Whitebark pine and subalpine fir occur in patches throughout the Reference State with infrequent and very low cover of incidental species: Engelmann spruce, mountain hemlock and subalpine larch. You know you have entered this timberline ecological site from the subalpine forest below when trees appear to be stunted and generally far less than 50 feet tall. You have also left the more complete canopy of the subalpine forest and entered the timberline area when observed trees are stunted and growing in clumps. Further upslope trees and clumps

gradually become smaller and less as one enters the higher, treeless alpine zone. The severe site conditions cause the vascular plant species diversity to be fairly low, constrained to species that can survive in these harsh conditions. Soils associated with this ecological site are deep and well drained and are on steep mountain slopes. Due to the high amount of rock fragments throughout these soils their ability to hold and store water is limited. Active slope processes and erosion limit the amount of soil development causing these soils to be classified in the Inceptisols soil order. Soil parent material is primarily from colluvium, which can be mixed with glacial till, derived from metasedimentary rocks of the Belt super group.

Associated sites

R043AX962MT	**Alpine Unstable Talus rocky ledge penstemon (Penstemon ellipticus)** The alpine unstable talus ecological site resides on extensive talus slopes on very steep to steep slopes with a surface dominated by large rock fragments or talus. The landforms are cirque headwalls, colluvial aprons and glacial valley walls.The alpine unstable talus ecological site has soils that are deep, well to somewhat excessively drained and have abundant rock fragments throughout. These soils are generally classified in the Entisols or Inceptisols soil orders, indicating that they have virtually no soil development because they are on active positions of the landscape or have only weakly developed soil diagnostic characteristics. The alpine unstable talus ecological site has a reference vegetation community of Rocky ledge penstemon (Penstemon ellipticus), buttecandle (Cryptantha celosioides), silverleaf phacelia (Phacelia hastata) and alpine leafybract aster (Symphyotrichum foliaceum).
R043AX971MT	**Alpine Solifluction Terrace Dryas octopetala (Arctostaphylos uva-ursi/Salix arctica)** The 43A Alpine Solifluction Terrace ecological site is found at high elevations 1,700-2,600 m (5,575-8,530 ft.) on ridges or backslopes in the mountains or cirque floors mainly on northern or western aspects of moderate to steeper slopes (10-40 percent). Due to frost heave action, solifluction terraces have developed, in which there is a sorting of gravels and vegetation into stripes.The 43A Alpine solifluction terrace ecological site has soils that are moderately deep, well drained, and very gravelly in the surface and subsurface. The highest expression of this site has areas of alternating strips covered by vegetation and rock terracing which has low to moderate vegetation cover.The 43A Alpine Solifluction Terrace ecological site has a reference vegetation community of eightpetal mountain-avens (kinnikinnick-arctic willow-moss campion-twinflower sandwort)/alpine smelowskia-cutleaf daisy-alpine bistort/curly sedge.

Table 1. Dominant plant species

Tree	(1) *Abies lasiocarpa* (2) *Pinus albicaulis*
Shrub	(1) *Vaccinium scoparium*
Herbaceous	(1) *Luzula glabrata var. hitchcockii* (2) *Xerophyllum tenax*

Physiographic features

The 43A alpine krummholtz coniferous site is found along the Continental Divide in the severe, cold, high elevations of the upper subalpine and timberline zones. The dominant landform is cirque headwalls, on backslope positions, at elevations ranging from 1600 to 2700 meters. This site occurs on all aspects and generally on steeper slopes ranging from 15 to 80 percent. It is above the cold limits of species including Douglas fir, grand fir, western white pine, lodgepole pine, and western larch. Whitebark pine and subalpine fir dominate the Reference Phase with infrequent and very low cover of incidental species: Engelmann spruce, mountain hemlock and subalpine larch. The severe site conditions cause the vascular plant species diversity to be fairly low, constrained to species that can survive in these harsh conditions. This is a timberline site that is defined by the presence of whitebark pine and subalpine fir growing in clumps with open areas in between. Due to extreme conditions, the trees may grow in a dwarf krummholtz form while the understory grows in mosaics. This pattern of krummholtz forest with open wetter areas in between have been called “ribbon-forests” (Billings, 1969). Geologic and geomorphic controls via bedrock strike and dip are largely responsible for the creation of conditions suitable to the formation of ribbon forests in bedrock areas of thinly bedded Belt Supergroup metasedimentary rocks (Fagre et al., 2003). The pattern of these bands of forests create snow catchment areas on their leeward sides that further reinforce the selection of meadow areas by making it difficult for trees to establish. Trees occupy the higher, parallel to subparallel, well drained sites where the spatial pattern is a distinct reflection of the bedrock structure and stratigraphy. The meadow areas occupy the concave positions between ridges where erosion along bedding plane strike was concentrated (Bekker, 2003).

Figure 1. Site photo, notice high elevation setting and tree islands within the beargrass dominated slopes.

Figure 2. Site photo, notice high elevation setting below alpine unstable talus slopes and krummholz tree island with very little bare ground.

Figure 3. Landscape view of this ecological site, notice small tree islands.

Table 2. Representative physiographic features

Landforms	(1) Mountains > Cirque headwall (2) Mountains > Moraine (3) Mountains > Mountain slope
Elevation	579–701 m
Slope	40–60%
Aspect	W, NW, N, NE, E, SE, S, SW

Table 3. Representative physiographic features (actual ranges)

Elevation	488–823 m
Slope	15–80%

Climatic features

This ecological site is found in the cryic soil temperature regime and the udic soil moisture regime. Cryic soils have average annual temperature 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.

Mean Average Annual Precipitation (40-102 inches)
Mean Average Annual Temperature -2.7 to 4 celsius/ 27-39 degrees F
Frost free days: >15-30
Relative Effective Annual Precipitation: 127-254cm (50-100 inches)
CLIMATE STATIONS AVAILABLE ARE LOCATED IN VALLEYS AND MAY NOT BE REPRESENTATIVE OF THIS SITE. THE ABOVE INFORMATION IS REPRESENTATIVE.

Table 4. Representative climatic features

Frost-free period (characteristic range)	57-86 days
Freeze-free period (characteristic range)	111-131 days
Precipitation total (characteristic range)	533-737 mm
Frost-free period (actual range)	17-87 days
Freeze-free period (actual range)	75-132 days
Precipitation total (actual range)	508-813 mm
Frost-free period (average)	66 days
Freeze-free period (average)	116 days
Precipitation total (average)	635 mm

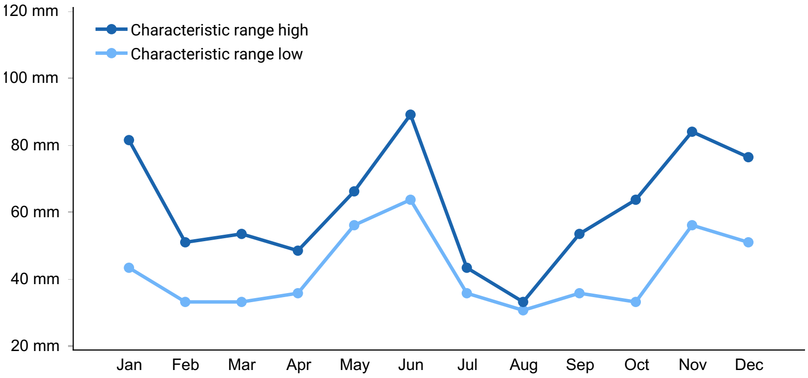


Figure 4. Monthly precipitation range

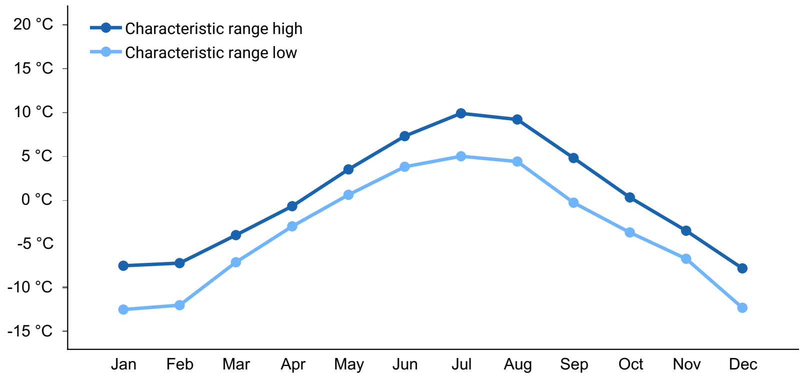


Figure 5. Monthly minimum temperature range

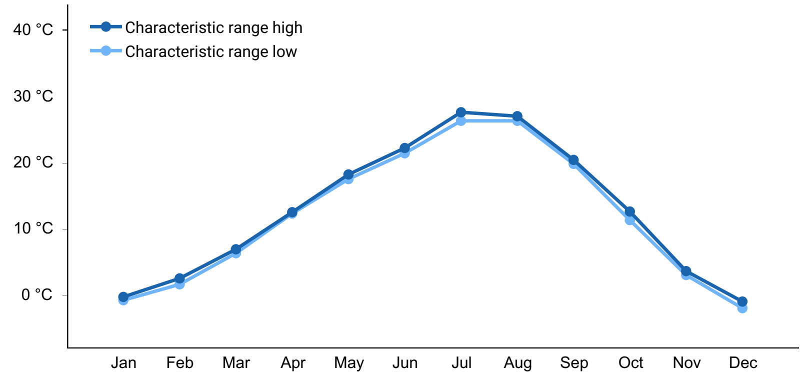


Figure 6. Monthly maximum temperature range

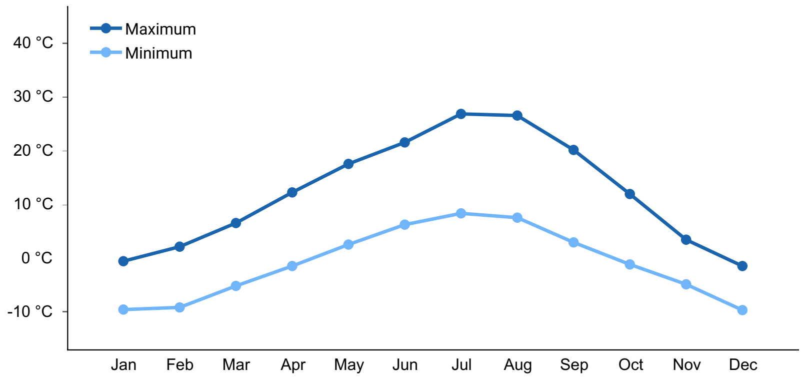


Figure 7. Monthly average minimum and maximum temperature

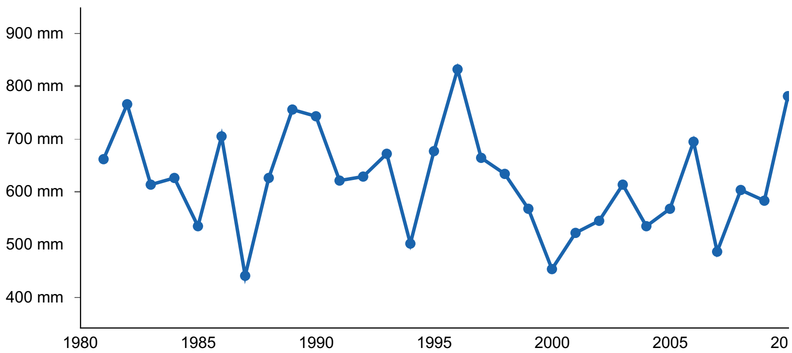


Figure 8. Annual precipitation pattern

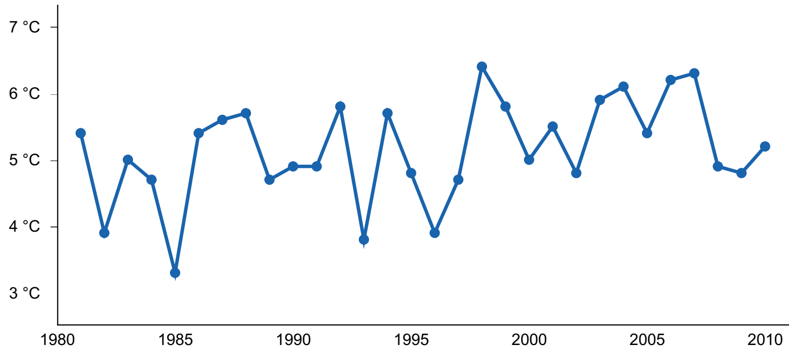


Figure 9. Annual average temperature pattern

Climate stations used

- (1) POLEBRIDGE 1 N [USC00246618], Essex, MT
- (2) POLEBRIDGE [USC00246615], Essex, MT
- (3) WEST GLACIER [USC00248809], Kalispell, MT
- (4) WHITEFISH [USC00248902], Whitefish, MT
- (5) LINDBERGH LAKE [USC00245043], Seeley Lake, MT
- (6) HUNGRY HORSE DAM [USC00244328], Kalispell, MT

Influencing water features

Soil features

Soils associated with this ecological site are deep and well drained and are on steep mountain slopes. Due to the high amount of rock fragments throughout these soils their ability to hold and store water is limited. Active slope processes and erosion limit the amount of soil development causing these soils to be classified in the Inceptisols soil order. Soil parent material is primarily from colluvium, which can be mixed with glacial till, derived from metasedimentary rocks of the Belt super group. The most common rock types includes argillite and siltite. The diagnostic features in these soils are an ochric epipedon and cambic horizon indicating weak soil development (Soil Survey Staff, 2015). Soils found under dense krummholtz vegetation may have a very thin organic duff layer at the soil surface. Soils in areas with beargrass vegetation tend to be darker overall in color and have more organic matter than those under krummholtz patches.
SOIL SERIES: NOONEY (old name Ahern)
Taxonomic class: Loamy-skeletal, mixed, superactive Typic Haplocryepts

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

Figure 10. Soils associated with this ecological site.

Table 5. Representative soil features

Parent material	(1) Colluvium–metasedimentary rock (2) Residuum–metasedimentary rock
Surface texture	(1) Very gravelly silt loam
Drainage class	Well drained
Permeability class	Moderately rapid
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (Depth not specified)	4.57–9.65 cm
Soil reaction (1:1 water) (Depth not specified)	4.5–6.5

Ecological dynamics

ECOLOGICAL DYNAMICS OF THE SITE
STATE 1
The 43A Alpine Krummholtz Coniferous Ecological site is found along the Continental Divide in cold, high elevation sites in the upper subalpine and timberline zones. These sites are above the cold limits of Douglas fir, western white pine, western larch, and lodgepole pine with common species including whitebark pine, subalpine fir and Engelmann spruce and alpine larch. Trees are stunted, generally far less than 50 feet tall, and growing in clumps with the understory growing in mosaics. The stands are composed of whitebark pine and subalpine fir, with Engelmann spruce and alpine larch in a minor extent. The understory is not overly diverse: it is composed of only a few important species. Shrubs can include grouse whortleberry, pink mountainheath, and yellow mountainheath. There may be high cover of grouse whortleberry and/or Hitchcock's smooth woodrush, which are indicative of cold climate conditions. Common forbs that may occur on these sites are broadleaf arnica, beargrass, Ross' sedge, Idaho fescue, Parry's rush, and Hitchcock's smooth woodrush. Primary data was collected in Glacier National Park (NP) in Montana.

This ecological site is described as having cold and severe site conditions, with a fire return interval of 35 to over 300 years, with fire typically of low severity due to discontinuous fuels. Stand replacement fires occur after intervals of more than 200 years, typically during drought conditions and generally brought upslope from severe wind-driven crown fires burning in lower elevation forests. Forest fuels typically are relatively sparse fine fuels and moderate to heavy loads of widely scattered large diameter fuels. These larger fuels are from wind and snow breakage, windthrow, and mortality caused by insects and disease. The normally cool and moist site factors, short fire season, and the sparse, discontinuous, fine surface fuels layer lead to low fire severity. If dry conditions prevail, such as extended drought, then stand-replacing fire can occur. Vegetation succession afterwards is slow due to the extremely short growing season. Climatic site factors tend to control the production of these sites: the high rock and snow cover with low, discontinuous surface fuels and generally low vegetation production are more important to forest development than fire. Lightning fires do occur, but the rain that accompanies thunderstorms and the discontinuous fuels limit fire occurrence, spread, and severity. Fire is important in perpetuating an abundance of whitebark pine.

The general post-disturbance successional phases include the stand initiation phase dominated by herbaceous and shrub species and conifer seedlings, the young stand of pole-sized mixed conifers, the maturing forest of overstory mixed conifer trees, and the Reference Phase with small gap dynamics. A stand-replacing fire in the mature forest or Reference Phase would result in the stand initiation phase with species composition of seedlings varying with site conditions. The stand initiation phase will dominate for an extended period, up to 100 years, maintained by site conditions that allow physical disruption of the stand including snow load, windthrow, rock slides, and talus slippage. Whitebark pine, Engelmann spruce, subalpine fir, and alpine larch seedlings can occupy this site and will progress to the young stand with no major disturbance. Fire is unlikely in these earlier successional phases, but can occur as surface fires or severe fires of limited extent, which create vegetative mosaics. The stand progresses to the mature phase, during which heavier fuels from breakage or mortality may accumulate and allow stand-replacing fires in periods of extended drought. Without disturbance, the mature stand progresses to the Reference Phase, which is rarely affected by fires of low to moderate severity because of the open structure of the forest and discontinuous fire woody fuels. Stand-replacing fires that do occur can return the site to the stand initiation phase.

Significant fires that have occurred on the west side of the Continental Divide that have effected this ecological site include: Kootenai in 1998 that burned 8,041 acres, Trapper in 2003 (18, 453 acres), rampage Complex in 2003 (23,237 acres) and the Wedge in 2003 (53,570 acres). These fires burned areas primarily below this ecological site, but did effect this ecological site to a smaller extent.
Significant fires that have occurred on the east side of the Continental Divide that have affected this ecological site include the Red Eagle fire in 1998 that burned 45,559 acres. This fire burned areas primarily below this ecological site, but did affect this ecological site to a smaller extent.

Whitebark pine is considered a keystone species of this ecosystem. It is a slow-growing, long-lived tree that is well adapted to the severe, exposed conditions of the timberline zone. It is vital to wildlife through its nutritious seeds (large, wingless, less perishable than others with high fat and protein content) which are collected and buried by Clark’s nutcrackers, and collected and stored in middens by pine and red squirrels, which can be raided by grizzly and black bears for winter food. There are many plants, animals, and insects that depend on whitebark pine. Clark’s nutcrackers are the obligate seed dispersal source for whitebark pine. The structure and physical location of whitebark pine control snowmelt via the broad crowns that collect snow and shade it during spring, which melts out gradually, helping to slow spring runoff and allow for a more continuous water supply throughout the dry summer months (Asebrook, 2012). White bark pine is particularly susceptible to mountain pine beetles, white pine blister rust, red belt fungus, pini rot, needlecast, pine cone beetles, and western conifer seed bugs. Whitebark pine may be replaced by means of succession by more shade-tolerant species, such as subalpine fir, due to fire suppression coupled with damage from mountain pine beetles and white pine blister rust (Arno, 1986).

During the past several decades, whitebark pine has had considerable decline in numbers throughout its range. In 2011, the U.S. Fish and Wildlife Service placed whitebark pine as a high priority on the candidate species list of Endangered or Threatened species (U.S. Fish and Wildlife Service, 2011). Whitebark pine is imperiled mainly by white pine blister rust, but also by mountain pine beetles and fire suppression. A comparison study of whitebark pine in two major ecosystems found that for the Northern Divide Ecosystem (including Glacier NP) and the Greater Yellowstone Ecosystem (including Yellowstone NP), the overall stand densities were similar; however, the northern had only 79 live whitebark pine trees per hectare compared to 274 in the southern. White pine blister rust, crown die-off and mortality were all significantly greater in the northern forests. Nearly 75 percent of all whitebark pine were dead and approximately 90 percent of the remaining whitebark pine were infected with rust (Fiedler and McKinney, 2014). Whitebark pine habitat in Glacier NP was once extensive, with a study in 1996 finding 87,500 acres as potential seral whitebark pine habitat, with the majority of this on the east side of Glacier NP(Peterson, 1999). White pine blister rust is a fungus introduced to North America in the early 1900s from Europe via Asia, which causes branch and stem cankers that eventually lead to top-kill or death. Since cone-producing branches die first, there are less cones for wildlife, which could have cascading effects throughout the ecosystem. Rust affects five-needle pines, including western white, limber, and whitebark pines; Ribes species are the most common alternate hosts. Other hosts do exist, including louseworts and Indian paintbrush. A study of white pine blister rust in treeline whitebark pine in Glacier NP found rates of infection varied considerably, and that factors contributing to higher rates included sites exhibiting high flow accumulation rates, greater distances to wetlands, slopes facing southwest, higher curvature, greater wind speeds, and close proximity to Ribes and perennial streams (Smith, E., et al 2011). Mountain pine beetles feed on the phloem layer of the inner bark of most species of pine. This feeding girdles the tree and the tree is inoculated with blue stain fungi, which disrupts the water transport system and the tree is killed. There can be large outbreaks of this beetle to epidemic proportions in lower elevation lodgepole pine stands, and the beetles can move upward into whitebark pine stands. This can be very detrimental if trees are already stressed by drought or blister rust, or by overcrowding by subalpine fir or Engelmann spruce. Lack of fire can increase subalpine fir or Engelmann spruce, which could stress pines. Fire is needed by whitebark pine for seedlings to thrive, as well, Clark’s nutcrackers prefer burns for seed caches. Restoration of whitebark pine includes harvesting cones from rust-resistant trees, then growing and planting rust-resistant seedlings, allowing fire-created openings where nutcrackers can cache seeds and seedlings can grow, and the use of beetle-repelling pheromone on trees to prevent beetle attacks on sites. In 1997, the National Park Service (NPS) began collecting seed from whitebark pine and limber pine trees that showed phenotypic rust resistance, growing in a nursery, and monitoring growth. From 2000-2007 they planted 6,400 whitebark pine and 4,700 limber pine seedlings, and found in 2010 that 41 percent of whitebark pine had survived, while only 6 percent of the limber pine survived (Asebrook et al., 2001). Unfortunately, another study modelling the effects of climate change and fire frequency and severity on whitebark pine stands concluded that the presence of whitebark pine would likely reduce, suggesting that conservation and restoration efforts must target multiple threats of interacting disturbance agents (Keane and Loehman, 2010).

Although subalpine fir can be subjected to a variety of diseases and insect pests, the effects of these disturbance factors within this near-timberline ecological site have not resulted in significant damage to subalpine fir and Engelmann spruce to the extent seen in lower elevation ecological sites dominated by subalpine fir or Engelmann spruce (USDA USFS ADSM 2014). Diseases and insect pests that can affect subalpine fir include root rot, stem decay, bark beetles, and wood borers and defoliators. These can weaken and or kill trees and result in small openings scattered throughout the forest, or major mortality during an outbreak such as western spruce budworm (Choristoneura occidentalis). Windthrow is a common disturbance after weakening of root systems. Subalpine fir is most commonly susceptible to Armillaria and Annosus root disease, and the pouch, Indian paint, and red belt fungi, which cause stem decay. Subalpine fir also is susceptible to metallic, roundheaded, and Western balsam bark beetles, fir canker, and defoliators such as Delphinella shoot blight, black mildew, brown felt blight, fir needle cast, snow blight, and fir-blueberry rust.

The alpine krummholtz coniferous ecological site can be associated with slopes dominated by the forb species beargrass (*Xerophyllum tenax*) particularly on southerly facing aspects of steep sloping (20-40%) backslope positions on mountain slope and cirque wall landforms. Harsh site conditions, frequent avalanches, frequent spotty and low intensity fires and soil conditions can contribute to the dominance of beargrass. Beargrass is particularly suited to withstanding the harsh site conditions and avalanches by its mat-forming physiology. The frequent spotty and low intensity fires keep tree encroachment to a minimum while not eliminating the growing points of beargrass. The soils tend to not hold water and are therefore more prone to droughty conditions, which beargrass can withstand. As well, slope processes and erosion from avalanches lead to less developed soils in which beargrass can thrive. These slopes are dominated and stabilized by the mat-forming and long lived member of the lily family, beargrass (Laursen, 1984). When whitebark pine or subalpine fir occur on these slopes, they are stunted and form small islands within the beargrass dominated slope. This community is dominated by beargrass, but also has significant cover of the shrubs thinleaf huckleberry and grouse whortleberry. The herbaceous layer is diverse and includes false green hellebore, sitka valerian, and western meadow-rue. The total annual production for the beargrass slopes average 7,216 pounds per acre, predominantly from beargrass (6,405 pounds per acre). The foliar cover is very high (84% total foliar cover) for the beargrass slopes.

Beargrass is a perennial, evergreen plant that forms thick tussocks (Hitchcock, 1969). It has linear leaves that are scabrous and wiry. Beargrass blooms cyclically and may go many years without blooming: colonies of beargrass bloom in 5-7 year cycles (Stickney, 1981). Beargrass slopes can be exceptionally beautiful during flowering. It reproduces both by seed, which needs cold stratification for germination, and vegetatively by offshoots of the rhizome. After disturbance, vegetative resprouting from rhizomes allows for recovery (Antos, 1980). Beargrass is a survivor species that will resprout and regrow in place after fire. The meristematic region, or growing point, of beargrass is at or above the interface between organic material and mineral soil. Therefore, duff-consuming or severe fires that damage the meristematic region can kill beargrass (Arno, 1985). It has been found in Waterton Park, to the north of Glacier National Park, on moderate to steep south-facing slopes on colluvial and moraine landforms with Engelmann spruce, subalpine fir and whitebark pine (Achuff, 1989). The fire regime of these beargrass dominated slopes is similiar to the general vegetation community of the alpine timberline krummholtz coniferous ecological site, which has a fire-return interval of 35 to over 300 years; the fire typically is of low severity due to discontinuous fuels. Stand replacement fires occur after intervals of more than 200 years; these occur typically during drought conditions and are brought up by severe wind-driven crown fires from forests at lower elevations. Beargrass can be very sensitive to competition by shrubs after disturbance by severe fire with resident fire-tolerant shrubs (Stickney, 1981). It is moderately shade tolerant, growing best in full sun. Nimlos (1981) found that beargrass was associated with soils that had an ash layer. We found that to hold true for most of our sites. Site conditions can be harsh with steep slopes, high elevation, and therefore cold conditions and shorter growing seasons. Beargrass is uniquely adapted to thrive in these site conditions. The slopes are stabilized by the dense mat-forming nature of beargrass roots (Halverson, 1986). As well, the leaves of beargrass are adapted to forces from snow load and frequent snow avalanches occurring from site conditions. Site conditions also give beargrass a competitive advantage over conifer species, which generally are stunted in the krummholtz form when they occur on this site. Conifer regeneration also is difficult due to cold subsurface soil temperatures, high surface temperatures after snowmelt, rapid soil drying, beargrass-sedge mats, pocket gophers, and a short growing season with prolonged frosts (Smart, 1977). The stabilization of the slope is from fine root fibers that extend down into the soil 12-15 cm (Damm, 2001). This extensive fibrous root system and the prostrate growing basal shoots are extremely resistant against soil creep and erosion: they stabilize the slopes and therefore the whole vegetation community. Very little bare ground exists at this site. Site conditions, such as steepness which provides good drainage and southerly aspects leading to dry conditions in late summer and fall, are perfect for the xerophilic beargrass. The ridged, sedge-like leaves of beargrass are adapted to drought, wind desiccation, and snow load (Damm, 2001). Snow loads can be high, but slopes melt out early in comparison to other slope aspects which can lead to summer drying. Also, beargrass is evergreen, which provides a much quicker start to springtime assimilation. Beargrass and grouse whortleberry are adapted to snow avalanches as well by their morphological attributes: beargrass has long, slender leaves and grouse whortleberry has broom-like flexible branches (Daubenmire, 1968). Beargrass is very hardy: it's very frost tolerant and, because of its tough, wiry leaves and tufted growth form, beargrass is tolerant of human trampling (Cole, 1987).

STATE 2
Another disease affecting this ecological site is root rot, although to a lesser extent than adjoining ecological sites at lower altitudes. Armillaria root disease is the most common root disease fungus in this region, and is 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 of dense brush, and seedlings and saplings of susceptible tree species may be present that will eventually succumb to the root rot as they grow, usually at less than thirty years of age. The growth is in the center of the root rot. Armillaria is present in most stands in western Montana and northern Idaho, 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 to identify the type of Armillaria root disease is 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 (Hagel, USFS July 2010). A link has been postulated between parent material and susceptibility to root disease: 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 root disease mortality, then a coniferous stand could cross a threshold and become a shrubland, once all conifers are gone (Kimsey et al., 2012).

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 for ecological services like water quality and quantity, old growth, or endangered species.

The US Forest Service (USFS) Habitat Type guide states that the basal area on the eastern side of the Continental Divide for PIAL-ABLA is 247+/-63 ft2 per acre and site index at 50 years for Abies is 25. The USFS Habitat Type guide states that the basal area on the West side of the Continental Divide for whitebark pine-subalpine fir (PIAL-ABLA) is 146+/-46 ft2 per acre and site index at 50 years for Abies =16. Timber production on these sites is very low, and rarely an important management objective. Watershed management is very important, as well as wildlife sanctuaries. Each national forest has a specific management plan. The management plan for the Flathead National Forest (NF) also has an Appendix B that gives specific management guidelines for habitat types (which relate to 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 PIAL-ABLA is common on the Flathead NF, located just west of GNP. The following is a personal communication with a sivicultural forester on management of PIAL-ABLA on the Flathead N.F.

These HTs are not typically managed since they are usually in areas that are unsuitable for timber production under our forest plan. The majority of management is taking advantage of recent wildland fires to plant whitebark pine. The fire kills subalpine fir and accomplishes site preparation for whitebark pine planting. Planting is typically done on a 15-foot spacing (200 TPA) and locating the seedlings next to shade is key. Micro-siting is so important in planting whitebark pine that we pay the planters by the hour instead of by the acre when planting whitebark pine. The thought is that paying by the hour will provide incentive to the planters to look for micro sites shaded from the afternoon sun. The Condon Mountain fire and the Spotted Bear fires recently provided new areas to plant whitebark pine. Before those fires we were starting to run low on acres suitable to plant whitebark pine. Some planning projects are now proposing slashing and prescribed burning to prepare conditions for whitebark pine planting. We cannot plant in Wilderness Areas which hold much of these habitat types. Subalpine fir encroachment will be a future problem in the areas planted with whitebark pine.

STRUCTURE: Multistory with small gap dynamics.
Community Phase 1.1
The overstory is dominated by whitebark pine and subalpine fir that is stunted with small gap dynamics in which small numbers of trees are dead and conifer regeneration is infilling. The canopy cover ranges from 10-20 percent. The ground cover consists predominantly of litter and duff with very low cover of embedded litter, moss, and soil. This community phase is multistoried with a lower tree layer of subalpine fir at 90 inches tall, with a shorter understory layer of forbs and
grasses less than 20 inches tall including beargrass, western meadow-rue, thinleaf huckleberry, and others. At these higher elevations, subalpine fir is 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 specie, although the potential for this is very low. The understory of this community has the medium-statured thinleaf huckleberry and beargrass. At this phase, Armillaria root rot can have a low impact.
Community Phase Pathway 1.1a
This pathway represents a larger disturbance, such as an insect infestation, wind storm, or rot pocket to create this forest structure. Areas of regeneration range from approximately 2 to 5 acres.

Table 2. Forest overstory summarization of canopy cover, basal area and site index.
FOREST OVERSTORY.
Forest canopy Canopy cover range 10-40%
Basal Area ranges Site index at 100 years: ABLA=30-40 CMAI=26@150 years

COMMUNITY PHASE 1.2:
Structure: high cover of herbaceous and shrub species with patchy clumps of regeneration of seedlings and saplings.
Community Phase 1.2 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, but generally include whitebark pine, Engelmann spruce, subalpine fir, and subalpine larch (*Larix lyallii*). The canopy cover is very low. This phase generally is tolerant to Armillaria root rot.

Community Phase Pathway 1.2a
This pathway represents continued growth over time with no further major disturbance.

COMMUNITY PHASE 1.3:
Structure: Clumps of single-story conifer species including whitebark pine, Engelmann spruce, subalpine fir, and subalpine larch. This phase generally is tolerant to Armillaria root rot.

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

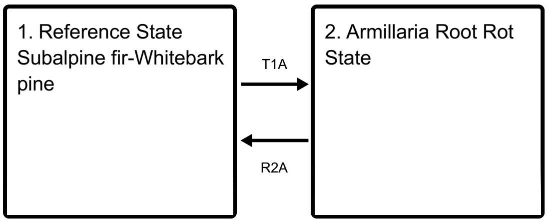
COMMUNITY PHASE 1.4:
Structure: Mature-sized trees of mixed conifers including whitebark pine, Engelmann spruce, subalpine fir, and subalpine larch. This phase generally is tolerant to Armillaria root rot.

Community Phase Pathway 1.4a
This pathway represents continued growth over time with no further major disturbance.

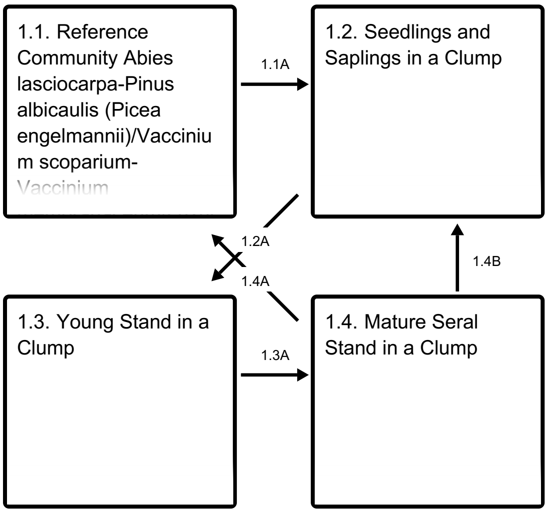
Community Phase Pathway 1.4b
This pathway represents major disturbance such as Armillaria root rot, stand-replacing fire, or pest outbreak.

State and transition model

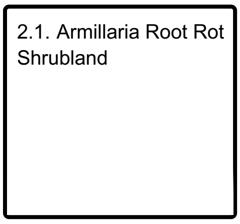
Ecosystem states



State 1 submodel, plant communities



State 2 submodel, plant communities



State 1
Reference State Subalpine fir-Whitebark pine

Community 1.1
Reference Community Abies lasciocarpa-Pinus albicaulis (Picea engelmannii)/Vaccinium scoparium-Vaccinium membranaceum/Luzula glabrata var. hitchcockii-Xerophyllum tenax/Veratrum viride-Valeriana sitchensis/Erythronium grandiflorum.

Figure 11. Short statured tress that form islands interspersed with bare ground with some herbaceous cover.

Figure 12. Vegetation at ecological site, notice areas with bare ground at the ridge and some with higher herbaceous cover along slope.

Figure 13. Short statured trees with flagging of tree limbs, indicating harsh site conditions. Higher cover of surface fragments at this site.

Figure 14. Representative vegetation community for reference state.

This site is dominated by beargrass with patches of whitebark pine and subalpine fir that is stunted with small gap dynamics in which small numbers of trees are dead and conifer regeneration is infilling. The overstory tree canopy cover ranges from 10-20 percent. The ground cover typically consists predominantly of duff (83%), with very low cover of embedded litter, moss, and bare soil. If erosional processes occur or the site occurs on ridges, than the amount of bare soil would increase (up to 20%). Surface fragments can be quite high. The typical understory is dominated by thinleaf huckleberry, beargrass and Hitchcock's smooth woodrush. Infrequently, the understory can have tundra shrub species kinnickinnik and arctic willow, or lack the shrub component and have only Hitchcock's smooth woodrush and sedges. Species that occur with the highest count of frequency and canopy cover at 11 sites include: thinleaf huckleberry, beargrass and Hitchcock's smooth woodrush. From foliar data taken at 5 sites, this community phase is described as multistoried with a tree layer of subalpine fir and whitebark pine typically at 100 inches tall (range is 60-480 inches), the next layer is 60-80 inches tall and consists of Scouler's willow and rusty menziesia, the next layer is 20-30 inches tall and includes green false hellebore and thinleaf huckleberry, the next layer is 10-20 inches tall and includes beargrass, grouse whortleberry, white spirea and Hitchcock's smooth woodrush and lowest layer is less than 10 inches and includes yellow avalanche lily, heartleaf arnica, strawberry, violet species, and alpine leafy bract aster. At these higher elevations, subalpine fir is 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, although the potential for this is very low. At this phase, Armillaria root rot can have an impact, albeit low, because this phase has higher cover of subalpine fir which is a primary host for Armillaria root rot. At these high elevation sites, the risk to Armillaria root rot is low overall though. These tree island clumps are found within slopes that are a mixture of shrubs, forbs and grasses most commonly beargrass dominated. Two datasets were taken to describe this ecological site the tree island clumps and the beargrass dominated slope within which the tree clumps are found.

Community 1.2
Seedlings and Saplings in a Clump

Figure 15. Notice steep slopes, beargrass dominated with islands of short statured subalpine fir.

Structure: high cover of herbaceous and shrub species with patchy clumps of regeneration of seedlings that grow to saplings. Community Phase 1.2 is a forest in the stand initiation phase, possibly with scattered remnant mature trees (in lower, taller tree clumps). The composition of the seedlings depends upon the natural seed sources available, but generally include whitebark pine, Engelmann spruce, subalpine fir, and subalpine larch (*Larix lyallii*). The canopy cover is very low. This community phase can last a very long time due to harsh site conditions. This phase generally is tolerant to Armillaria root rot because it is a mixture of conifer species. At the reference phase, there is more subalpine fir which is a primary host to Armillaria root rot. In general, Armillaria root rot is rare at this high elevation site but does bear mentioning. In the beargrass dominated slopes with associated forbs and grasses, the beargrass and shrubs resprout after fast moving fires and the species composition changes minimally. A slow moving fire which kills the meristematic buds of beargrass or shrubs will kill the plant and an herbaceous community will ensue and eventually shrubs will reestablish via seed.

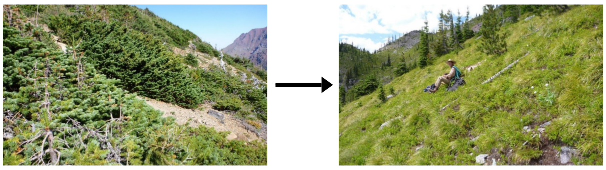
Community 1.3
Young Stand in a Clump

Structure: Clumps of young single-story conifer species including whitebark pine, Engelmann spruce, subalpine fir, and subalpine larch within the larger beargrass dominated slopes. At lower elevations, the taller tree clumps can be dense, pole sized trees. The higher elevation krummholtz tree clumps become thicker and denser, though not taller, with continued growth and establishment of regeneration. This phase generally is tolerant to Armillaria root rot because it is a mixture of conifer species. At the reference phase, there is more subalpine fir which is a primary host to Armillaria root rot.

Community 1.4
Mature Seral Stand in a Clump

Structure: Mixed mature reference and seral species conifer stand including whitebark pine, Engelmann spruce, subalpine fir, and subalpine larch. There is some vertical differentiation occurring in the lower elevation, taller, pole sized dense clumps of singe story conifers of community phase 1.3, due to single tree or small group of tree death due to windthrow, insects or disease. At higher elevations, the krummholtz form clump continues to grow thicker, larger though not taller. This phase generally is tolerant to Armillaria root rot because it is a mixture of conifer species. At the reference phase, there is more subalpine fir which is a primary host to Armillaria root rot.

Pathway 1.1A
Community 1.1 to 1.2



Reference Community Abies lasciocarpa-Pinus albicaulis (Picea engelmannii)/Vaccinium scoparium-Vaccinium membranaceum/Luzula glabrata var. hitchcockii-Xerophyllum tenax/Veratrum viride-Valeriana sitchensis/Erythronium grandiflorum.

Seedlings and Saplings in a Clump

This pathway represents a larger disturbance, such as fire, an insect infestation, wind storm, or rot pocket to create this forest structure. This transitions the reference community to post-fire disturbance phase of resprouting forbs, grasses, shrubs and regeneration of seedlings.

Pathway 1.2A
Community 1.2 to 1.3

This pathway represents time without major disturbance where deep rooted tree species such as whitebark pine and subalpine fir regenerate as they begin to exert a competitive advantage over shallower rooting grasses, forbs, and shrubs.

Pathway 1.3A
Community 1.3 to 1.4

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

Pathway 1.4A
Community 1.4 to 1.1

This pathway represents continued growth over time with no further major disturbance in which the mature stand of 1.4 becomes the reference stand which is dominated by subalpine fir and whitebark pine.

Pathway 1.4B
Community 1.4 to 1.2

This pathway represents major disturbance such as stand-replacing fire, disease or insect epidemic level outbreak.

State 2
Armillaria Root Rot State

Another disease affecting this ecological site is root rot, although to a lesser extent than adjoining ecological sites at lower altitudes. This ecological site is tolerant to the disease, but in the reference phase there is more subalpine fir which is a primary host to Armillaria root rot and the risk rises to a low impact. Armillaria root disease is the most common root disease fungus in this region, and is 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 of dense brush, and seedlings and saplings of susceptible tree species may be present that will eventually succumb to the root rot as they grow, usually at less than thirty years of age. The growth is in the center of the root rot. Armillaria is present in most stands in western Montana and northern Idaho, 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 to identify the type of Armillaria root disease is 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 (Hagel, USFS July 2010). A link has been postulated between parent material and susceptibility to root disease: 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 root 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 Shrubland

Metasedimentary and quartzite parent material (vitrandic soil on south and west aspects). Time= 50 years

Transition T1A
State 1 to 2

Significant loss of susceptible tree species at a site due to Armillaria root rot and conversion of the forest to a shrubland

Restoration pathway R2A
State 2 to 1

Conversion of the Armillaria root rot induced shrubland to forest, generally of less susceptible seral tree species and eventually to climax tree species. Refer to the management section under the plant community features for more information.

Additional community tables

Table 6. 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	–	0.5–37.5	–	–
whitebark pine	PIAL	*Pinus albicaulis*	Native	–	0.5–15	–	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	–	3–5	–	–

Table 7. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
sedge	CAREX	*Carex*	–	–	15
rush	JUNCU	*Juncus*	–	–	3–10
bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	–	–	3
bluegrass	POA	*Poa*	–	–	0.5
Drummond's rush	JUDR	*Juncus drummondii*	–	–	0.5
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0.5
shortstalk sedge	CAPO	*Carex podocarpa*	–	–	0.5
Idaho fescue	FEID	*Festuca idahoensis*	–	–	0.5
Forb/Herb					
common beargrass	XETE	*Xerophyllum tenax*	–	–	4–37.5
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–30
Rainier pleated gentian	GECA	*Gentiana calycosa*	–	–	3–15
Hitchcock's smooth woodrush	LUGLH	*Luzula glabrata var. hitchcockii*	–	–	1–15
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5–10
yellow avalanche-lily	ERGR9	*Erythronium grandiflorum*	–	–	3–10
Pacific anemone	ANMU	*Anemone multifida*	–	–	8
goldenrod	SOLID	*Solidago*	–	–	7
violet	VIOLA	*Viola*	–	–	7
mountain deathcamas	ZIEL2	*Zigadenus elegans*	–	–	5
Sitka valerian	VASI	*Valeriana sitchensis*	–	–	1–5
nodding onion	ALCE2	*Allium cernuum*	–	–	5
Indian paintbrush	CASTI2	*Castilleja*	–	–	4
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–3
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	2–3
anemone	ANEMO	*Anemone*	–	–	3
common yarrow	ACMI2	*Achillea millefolium*	–	–	0.5–3
orange agoseris	AGAU2	*Agoseris aurantiaca*	–	–	3
eightpetal mountain-avens	DROC	*Dryas octopetala*	–	–	2–3
white sweetvetch	HESU	*Hedysarum sulphurescens*	–	–	3

western blue virginsbower	CLOC2	*Clematis occidentalis*	–	–	3
miterwort	MITEL	*Mitella*	–	–	3
northern bedstraw	GABO2	*Galium boreale*	–	–	1–3
cinquefoil	POTEN	*Potentilla*	–	–	3
Rocky Mountain groundsel	PAST10	*Packera streptanthifolia*	–	–	2
white thistle	CIHO	*Cirsium hookerianum*	–	–	2
milkvetch	ASTRA	*Astragalus*	–	–	1
pale agoseris	AGGL	*Agoseris glauca*	–	–	1
yellow columbine	AQFL	*Aquilegia flavescens*	–	–	1
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	0.5–1
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	1
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5
vetch	VICIA	*Vicia*	–	–	0.5
rose	ROSA5	*Rosa*	–	–	0.5
Lyall's beardtongue	PELY2	*Penstemon lyallii*	–	–	0.5
beardtongue	PENST	*Penstemon*	–	–	0.5
slender cinquefoil	POGR9	*Potentilla gracilis*	–	–	0.5
alpine mountainsorrel	OXDI3	*Oxyria digyna*	–	–	0.5
rosy pussytoes	ANRO2	*Antennaria rosea*	–	–	0.5
broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	0.5
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5
Scouler's St. Johnswort	HYSCS2	*Hypericum scouleri ssp. scouleri*	–	–	0.5
roundleaf sundew	DRRO	*Drosera rotundifolia*	–	–	0.5
Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	0.5
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5
Shrub/Subshrub					
kinnikinnick	ARUV	*Arctostaphylos uva-ursi*	–	–	5–15
arctic willow	SAAR27	*Salix arctica*	–	–	15
shrubby cinquefoil	DAFR6	*Dasiphora fruticosa*	–	–	3–10
common juniper	JUCO6	*Juniperus communis*	–	–	3–10
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	1–8
pink mountainheath	PHEM	*Phyllodoce empetriformis*	–	–	0.5–6
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	3
American red raspberry	RUID	*Rubus idaeus*	–	–	3
Canadian gooseberry	RIOX	*Ribes oxyacanthoides*	–	–	0.5
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5
Tree					
subalpine fir	ABLA	*Abies lasiocarpa*	–	0–11.9	0.5–37.5
whitebark pine	PIAL	*Pinus albicaulis*	–	0–11.9	0.5–15
Engelmann spruce	PIEN	*Picea engelmannii*	–	0–11.9	3–5
Nonvascular					
spearleaf stonecrop	SELA	*Sedum lanceolatum*	–	–	0.5

Table 8. Community 1.2 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
sedge	CAREX	*Carex*	–	–	3–15
Hitchcock's smooth woodrush	LUGLH	*Luzula glabrata var. hitchcockii*	–	–	3–15
Drummond's rush	JUDR	*Juncus drummondii*	–	–	3
bluejoint	CACA4	*Calamagrostis canadensis*	–	–	3
mountain brome	BRMA4	*Bromus marginatus*	–	–	3
Forb/Herb					
common beargrass	XETE	*Xerophyllum tenax*	–	–	30–97.5
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	3–37.5
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–30
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5–15
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	0.5–15
common yarrow	ACMI2	*Achillea millefolium*	–	–	0.5–15
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–15
subalpine fleabane	ERPE3	*Erigeron peregrinus*	–	–	15
western showy aster	EUCO36	*Eurybia conspicua*	–	–	15
yellow avalanche-lily	ERGR9	*Erythronium grandiflorum*	–	–	3–10
Sitka valerian	VASI	*Valeriana sitchensis*	–	–	0.5–5
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	3
bracted lousewort	PEBR	*Pedicularis bracteosa*	–	–	3
yellow penstemon	PECO6	*Penstemon confertus*	–	–	0.5–3
Lyall's beardtongue	PELY2	*Penstemon lyallii*	–	–	0.5–3
pink mountainheath	PHEM	*Phyllodoce empetriformis*	–	–	3
cinquefoil	POTEN	*Potentilla*	–	–	3
bladder campion	SILA21	*Silene latifolia*	–	–	3
Indian paintbrush	CASTI2	*Castilleja*	–	–	0.5–3
sulphur-flower buckwheat	ERUM	*Eriogonum umbellatum*	–	–	0.5–3
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0.5–3
Asian forget-me-not	MYAS2	*Myosotis asiatica*	–	–	3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	3
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–3
alpine golden buckwheat	ERFL4	*Eriogonum flavum*	–	–	3
broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	3
arnica	ARNIC	*Arnica*	–	–	3
Rocky Mountain groundsel	PAST10	*Packera streptanthifolia*	–	–	2
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	0.5–1
stonecrop	SEDUM	*Sedum*	–	–	0.5
mountain deathcamas	ZIEL2	*Zigadenus elegans*	–	–	0.5
American alpine speedwell	VEWO2	*Veronica wormskjoldii*	–	–	0.5
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5
pointedtip mariposa lily	CAAP	*Calochortus apiculatus*	–	–	0.5

western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	0.5
rosy pussytoes	ANRO2	*Antennaria rosea*	–	–	0.5
dwarf fireweed	CHLA13	*Chamerion latifolium*	–	–	0.5
lanceleaf springbeauty	CLLA2	*Claytonia lanceolata*	–	–	0.5
splitleaf Indian paintbrush	CARH4	*Castilleja rhexiifolia*	–	–	0.5
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
northern bedstraw	GABO2	*Galium boreale*	–	–	0.5
Fern/fern ally					
northern hollyfern	POLO4	*Polystichum lonchitis*	–	–	0.5
Shrub/Subshrub					
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–37.5
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	0.5–15
dwarf bilberry	VACE	*Vaccinium cespitosum*	–	–	15
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–15
thimbleberry	RUPA	*Rubus parviflorus*	–	–	3–15
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	0.5–15
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	5
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–3
common snowberry	SYAL	*Symphoricarpos albus*	–	–	3
blueberry	VACCI	*Vaccinium*	–	–	3
red elderberry	SARA2	*Sambucus racemosa*	–	–	0.5
Canadian gooseberry	RIOX	*Ribes oxyacanthoides*	–	–	0.5
sticky currant	RIVI3	*Ribes viscosissimum*	–	–	0.5
American red raspberry	RUID	*Rubus idaeus*	–	–	0.5
green alder	ALVI5	*Alnus viridis*	–	–	0.5
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	0.5
Tree					
subalpine fir	ABLA	*Abies lasiocarpa*	–	0–11.9	5–30
quaking aspen	POTR5	*Populus tremuloides*	–	0–11.9	3
Nonvascular					
Moss	2MOSS	*Moss*	–	–	3

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Approval

Kirt Walstad, 9/08/2023

Rangeland health reference sheet

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

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:**