Ecological site F043AX952MT
Lower Subalpine Cool Moist Coniferous subalpine fir-Engelmann spruce/Rocky Mountain maple-thinleaf huckleberry/thimbleberry

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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 subalpine fir/queencup beadlily, which is further divided into phases with rusty menziesia and wild sarsaparilla as the relevant phases to this ecological site. This site relates to the USFS Habitat Type Group 7 and Fire Group 9. Both of these classification guides are specifically for the western Montana and northern Idaho region.
This ecological site relates to the NatureServe classification *Abies lasiocarpa-Picea engelmannii*/*Clintonia uniflora* Forest (CEGL005912).

Ecological site concept

Ecological Site Concept
The Lower Subalpine Coniferous Cool Moist and the Subalpine Coniferous Cool Moderately Dry ecological sites are the most expansive forested areas within Glacier National Park (GNP). This grouping is divided into moister versus drier aspects. This ecological site relates to the moister aspect of this grouping, and is indicated by either rusty menziesia (*Menziesia ferruginea*) or wild sarsapirilla (*Aralia nudicaulis*) as indicator species, in addition to the main indicator species *Clintonia uniflora*. It is in cool, moist mid-elevations that span the lower subalpine zone. This ecological site is found on back, foot and toeslope positions, on glacial valley wall and moraine landforms, on all slopes, at elevations ranging 1,000 to 2,100 meters (3,280-6,890 feet). Subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) are the dominant overstory species with co-occurring Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*). The main understory species are the medium sized shrub Rocky Mountain Maple, the mid height shrub Thinleaf huckleberry (*Vaccinium membranaceum*) with an understory of wild sarsaparilla, threeleaf foamflower and queencup bead lily (*Clintonia uniflora*). Soils associated

with this Ecological Site are very deep, well drained or somewhat excessively drained and have subsoils with abundant rock fragments. The parent material is volcanic ash over glacial till from metasedimentary rock. The volcanic ash found in these soils originates from the eruption of Mount Mazama (Crater Lake, Oregon) and is apparent in the soil profile as a surface mantle or series of layers in the upper part of the soil profile. Volcanic ash has properties that provide important additions to the subsurface soils that occur below the ash cap. Low bulk density, typically less rock fragments, and high water holding capacity increase the storage of water near the surface in soils with volcanic ash. In Soil Taxonomy, these soils classify primarily as Inceptisols soil order and more specifically as the Andic Haplocryepts taxonomic subgroup. Some areas may have Alfisols (with a volcanic ash cap) and Entisols, young soils that occur in erosional positions that can occur in association with the most commonly found ash-capped Inceptisols.

Associated sites

F043AX951MT	**Lower Subalpine Cool Dry Coniferous subalpine fir- Engelmann spruce/ Sitka alder/ thinleaf huckleberry/ common beargrass** This ecological site occurs on dry aspects in association with the reference ecological site.
R043AX968MT	**Montane Stable Colluvial Slope Saskatoon serviceberry-common snowberry/Sitka alder/ Rocky mountain maple/thimbleberry/mountain brome-Geyer's sedge** This associated ecological site is found in southerly or westerly aspects of drier mountain slopes adjacent to this ecological site.
F043AX955MT	**Subalpine Coniferous Cool Moist subalpine fir (Abies lasiocarpa)-Engelmann spruce (Picea engelmannii)** This associated ecological site is found at lower adjacent elevations.
F043AX954MT	**Upper Subalpine Cold Coniferous subalpine fir (Engelmann spruce) /thinleaf huckleberry-rusty menziesia/ Hitchcock's smooth woodrush-beargrass/yellow avalanche lily.** This associated ecological site is found at higher adjacent elevations.
F043AX957MT	**Lower Subalpine Frigid Coniferous western redcedar (Thuja plicata)-western hemlock (Tsuga heterophylla)**
R043AX961MT	**Subalpine Avalanche Rocky Mountain maple-Redosier dogwood Acer glabrum-Conus sericea ssp. sericea-Amelanchier alnifolia**

Table 1. Dominant plant species

Tree	(1) *Abies lasiocarpa* (2) *Picea engelmannii*
Shrub	(1) *Vaccinium membranaceum* (2) *Acer glabrum*
Herbaceous	(1) *Clintonia uniflora* (2) *Aralia nudicaulis*

Physiographic features

This site is found in cool, moister mid-elevations that span the lower subalpine to subalpine. This ecological site is found on back, foot and toeslope positions, on glacial valley wall and moraine landforms, on all slopes, at elevations ranging 1,000 to 2,100 meters (3,280-3,935 feet).

Table 2. Representative physiographic features

Landforms	(1) Mountains > Glacial-valley wall (2) Mountains > Lateral moraine (3) Mountains > Ground moraine
Elevation	1,000–2,100 m
Slope	25–45%
Aspect	W, NW, N, NE, E, SE, S, SW

Table 3. Representative physiographic features (actual ranges)

Elevation	Not specified
Slope	5–60%

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 Precipitation: 66-216 cm 26-85 inches
Mean Average Annual Temperature: 0-6 degrees C 32-43 degrees F
Frost-free days: 30-110
Relative Effective Precipitation: 127-254 cm 50-100 inches
SUMMARY TABLES ARE FOR AVAILABLE CLIMATE STATIONS WHICH ARE ALL LOCATED IN VALLEYS.

Table 4. 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

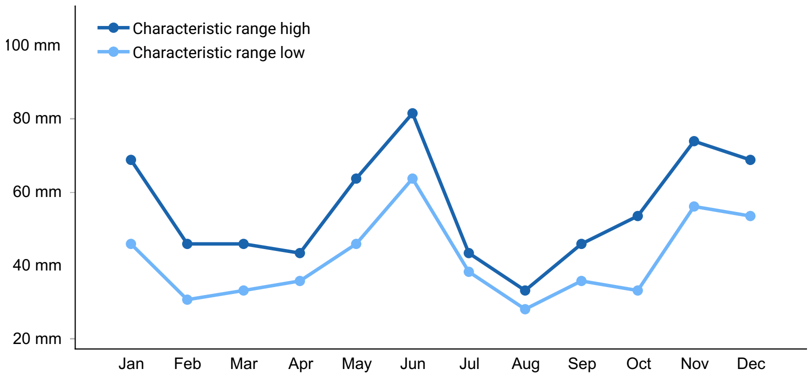


Figure 1. Monthly precipitation range

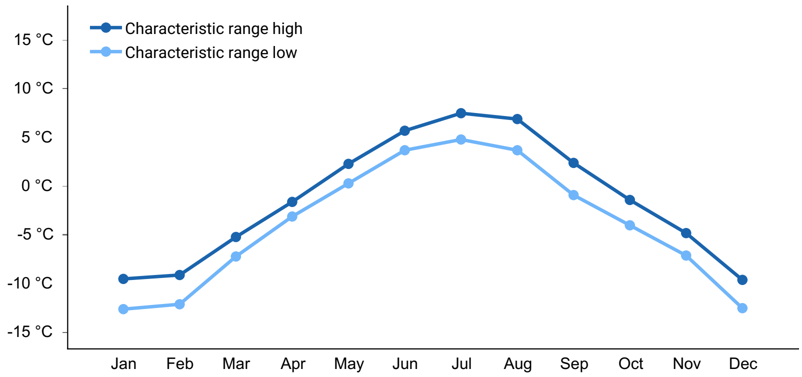


Figure 2. Monthly minimum temperature range

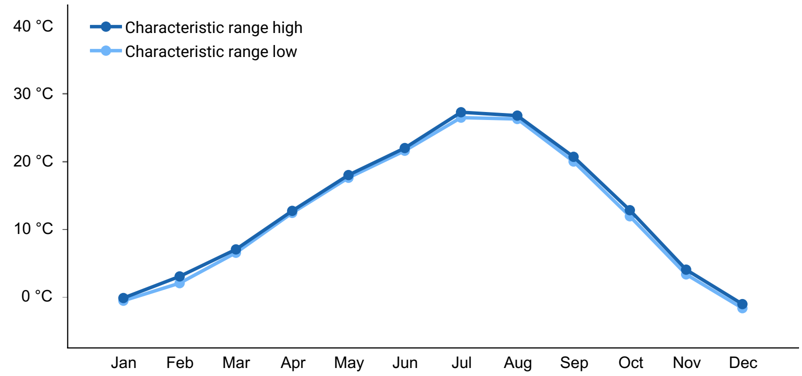


Figure 3. Monthly maximum temperature range

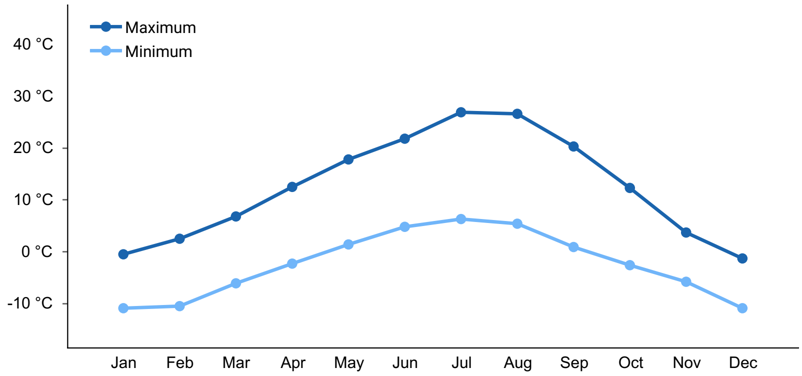


Figure 4. Monthly average minimum and maximum temperature

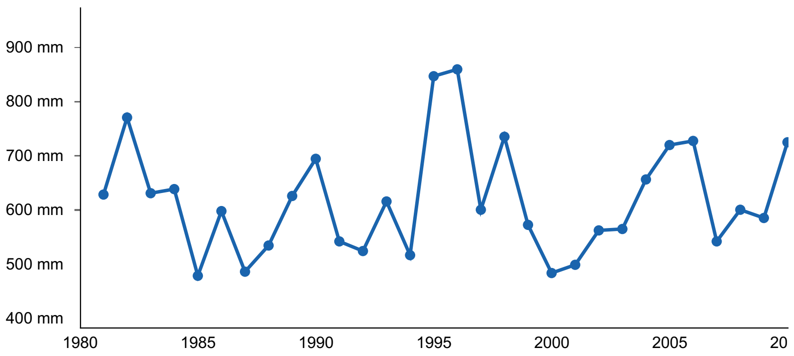


Figure 5. Annual precipitation pattern

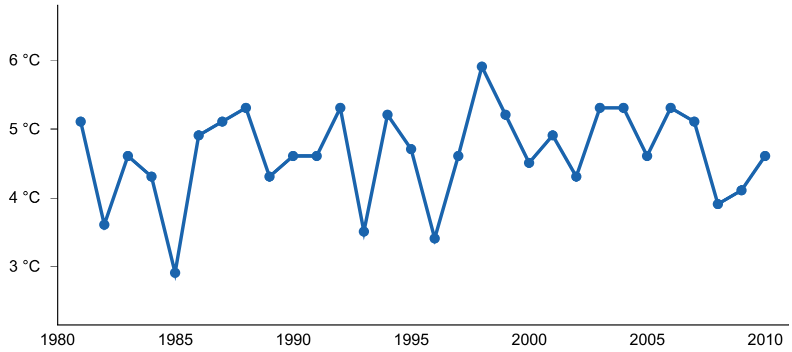


Figure 6. Annual average temperature pattern

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

Soils associated with this Ecological Site are very deep, well drained or somewhat excessively drained and have subsoils with abundant rock fragments. The parent material is volcanic ash over glacial till from metasedimentary rock. The volcanic ash found in these soils originates from the eruption of Mount Mazama (Crater Lake, Oregon) and is apparent in the soil profile as a surface mantle or series of layers in the upper part of the soil profile. Volcanic ash has properties that provide important additions to the subsurface soils that occur below the ash cap. Low bulk density, typically less rock fragments, and high water holding capacity increase the storage of water near the surface in soils with volcanic ash. In Soil Taxonomy, these soils classify primarily as Inceptisols soil order and more specifically as the Andic Haplocryepts taxonomic subgroup. Some areas may have Alfisols (with a volcanic ash cap) and Entisols, young soils that occur in erosional positions that can occur in association with the most commonly found ash-capped Inceptisols. Diagnostic features include an ochric epipedon, andic soil properties, and cambic diagnostic horizon (Soil Survey Staff, 2015). Under forest canopy cover is a thin surface layer of organic material present, usually less than 5 cm. (2 in.) 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
Cosely Sandy-skeletal, isotic, frigid Andic Eutrudepts
Elkridge Loamy-skeletal, isotic, frigid Andic Hapludalfs
Kaina Loamy-skeletal, mixed, superactive, nonacid Typic Cryorthents
Kegsprings Loamy-skeletal, mixed, superactive Typic Haplocryepts
Mohaggin Loamy-skeletal, mixed, superactive Andic Dystrocryepts
Risingwolf Loamy-skeletal, isotic Andic Haplocryepts
Rollins Sandy-skeletal, isotic, frigid Typic Dystrudepts
Watsondraw Loamy-skeletal, mixed, superactive Eutric Haplocryalfs

Figure 7. Soils associated with this ecological site.

Table 5. 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 (2) Gravelly, ashy loam
Family particle size	(1) Sandy-skeletal (2) Loamy-skeletal
Drainage class	Well drained to somewhat excessively drained
Permeability class	Moderate to moderately rapid
Soil depth	152–254 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (2.3-15.5cm)	Not specified
Soil reaction (1:1 water) (13-17.3cm)	Not specified

Ecological dynamics

Plant Community Features
Ecological Dynamics of the Site
The Lower Subalpine Coniferous Cool Moist and the Lower Subalpine Coniferous Cool Moderately Dry ecological sites are the most expansive forested areas within Glacier National Park (GNP). This grouping is divided into moister versus drier aspects. This ecological site relates to the moister aspect of this grouping, and is indicated by either rusty menziesia (*Menziesia ferruginea*) or wild sarsapirilla (*Aralia nudicaulis*) as indicator species, in addition to the main indicator species *Clintonia uniflora*. The 43A Lower Subalpine Coniferous Cool Moist ecological site is in cool, moist mid-elevations that span the lower subalpine zone. While primary data was collected in Glacier NP, this habitat type also spans into the adjacent US Forest Service (USFS) land Flathead National Forest (NF), and, in limited areas, the Kootenai NF.

Management
There are various management strategies that can be employed for this ecological site depending on 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 than it may be missing certain attributes necessary for lynx habitat. If a stand is managed for lynx habitat than you may have increased fuels and therefore 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/queencup beadlily is 248+/- ft2 per acre, and the site index at 50 years for Picea is 66 +/- 6 and for Abies is 59+/- 6. Timber production on these sites vary from low to very high. Water production within these areas are also important. The drier phases are less productive for timber and water than the wetter phases. This ecological site includes the wetter phases of this habitat type and high in timber production and water production and watershed management values. Timber productivity is highest in the wild sarsapirilla phase included in this ecological site. The ARNU2 phase generally is on gentle topography, but soft ground and a high water table during part of the growing season could limit certain extraction activities. The rusty menziesia phase, also included in this ecological site, has good water production but shrub development could be a problem after extraction activities. 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 the Cryic/Udic Coniferous ecological site.

The USFS habitat type subalpine fir/queencup beadlily 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 subalpine fir/queencup beadlily on the Flathead NF

Subalpine fir/queencup beadlily habitat type:

This habitat type is common, but colder types dominate the Flathead N.F. This is managed to promote western larch and western white pine. These species are tolerant or resistant to root disease and insect outbreaks (much more so than subalpine fir, Engelmann spruce or Douglas fir). Currently, there is an uptick of western spruce budworm potentially brought on by the current drier weather conditions. Another reason to promote western white pine is that it is expected to be adaptable in the face of climate change and to restore this species to the landscape after the significant mortality caused by the introduction of white pine blister rust. The current generation of resistant western white pine seedling stock shows up to 60% survival against white pine blister rust. Historically, this habitat type was managed using traditional even age strategies on the flathead national forest. Starting sixty years ago they regenerated a lot of this habitat type. Management also needed to employ intense methods to allow for scarification of the soil which is a regeneration requirement of western white pine. These methods included harvesting using skid trails and prescribed burns for site preparation. These methods are constrained because of soil and air quality concerns. Therefore, planting of western larch is employed instead and there is competition by Canada thistle and grass. As well, management on this habitat type is further constrained by concerns for Lynx habitat. Unless a unit is classified as WUI or is managed for western white pine, there is no pre-commercial thinning allowed in this habitat type. This inability to thin stands could cause forest stand health issues with root disease or insect outbreaks if the stand has significant density of the vulnerable species of subalpine fir, Engelmann spruce or Douglas fir. The inability to thin also greatly affects the diameter growth of individual trees. Traditional even-aged management on this type consists of pre-commercial thinning followed by commercial thinning to grow older larger western larch. A seed tree harvest leaving western larch and western white pine and large diameter Douglas fir and western larch snags for wildlife is used to regenerate a new stand. If a stand has sufficient ABLA then it might trip the snowshoe hare screen for the Lynx Amendment and then left alone. Multi-story structure of a stand and minimum cutting unit size is important for lynx habitat. As well, if a unit is deemed old growth then it is left alone even if these conditions make it susceptible to root rot or insect damage because these conditions are consistent with forest succession on this habitat type.

State 1.0 *Pinus monticola* (Abies lasciocarpa-*Picea engelmannii*)/*Acer glabrum*-Vaccinium membraneceum/*Rubus parviflorus*/*Aralia nudicaulis-Clintonia uniflora*

Historically western white pine would have been within Flathead County, which encompasses the Flathead NF and in lower elevations, west of the continental divide in Glacier NP. Originally, western white pine covered 5 million acres in the Inland Northwest. Western white pine is incredibly productive for timber, with a very high growth rate, is tall and deep–rooted, and competes best on highly variable, high resource sites. As well, it is tolerant to the native root rot diseases and other native forest pests, is susceptible to Armillaria root disease only when young, and is vulnerable to mountain pine beetle largely at advanced ages (over 140 years). It also has the capability to thrive in a wide variety of sites and environments, which means it has high ecological flexibility. It is a long-living seral species that tolerated intense timber harvesting practices and severe fire disturbance by its ability to regenerate heavily on mineral soil and in full sunlight. Fire greatly influences the composition, structure, and function of vegetation across the landscape. Historically, it was mixed severity fire in between severe stand-replacing fires. Western larch and western white pine are long-lived, fire-adapted, shade-intolerant tree species that thrived historically. Also present in significant amounts particularly in young stands, but which declined through time due to effects of insects and pathogens, were the shorter-lived, shade-intolerant, fire-adapted tree species such as Douglas-fir and lodgepole pine. Shade-tolerant, fire-intolerant tree species such as western cedar, western hemlock, grand fir, Engelmann spruce, and subalpine fir were present but rarely survived long enough to dominate stands, except where the interval between fires was unusually long and where root disease was not severe. Prior to the 20th century, western white pine was a major component in forested ecosystems of the inland northwest U.S., but has been greatly reduced in distribution and abundance by white pine blister rust, mountain pine beetles, and anthropogenic fire exclusion (Tomback and Achuff, 2010). Western white pine has been replaced by Douglas-fir, grand fir and western hemlock. Douglas-fir and grand fir are susceptible to a greater variety of insect and disease problems and hemlock is more sensitive to drought and decay. More stands have also progressed to the climax species-dominated phase, which previously were rarely achieved due to the fire rotations and susceptibility of these species to disease and forest pests. In a study of the effects of pathogens and insects on forests within the Inland Empire found that, excluding fire, more than 90 percent of sample stands changed to a different cover type, structure stage, or both during a 40-year period that was coincident with the blister rust epidemic and fire suppression policy. Root pathogens, white pine blister rust, and bark beetles were the cause of most changes and this accelerated succession of western white pine, ponderosa pine, and lodgepole pine to later successional, more shade-tolerant species. The structure was reduced in stand density or prevented canopy closure. Grand fir, Douglas-fir, and subalpine fir were the predominant cover types at the end of the period, and were highly susceptible to root diseases, bark beetles, fire, and drought. It is estimated that there will be greater accumulations occurring in low-density mature and younger pole-sized stands that result from root disease and bark beetle-caused mortality (Byler and Hagle, 2000). These stands also are less productive in terms of timber. They are dominated by species with high nutrient demands where nutrient storage and cycling rates are increasingly depressed. This will likely lead to ever-increasing stress and destabilization by pests and diseases. Drought can further exacerbate the situation by stressing trees. The Inland Empire Tree Improvement Cooperative and the USFS have a breeding program for blister-resistant western white pine. A total of approximately 5 percent of the original acre range has been planted with rust-resistant stock. Currently, the modified stock shows about 60 percent resistance to blister rust. A study modeling the effects of climate change found that warming temperatures would favor increased abundance of western white pine over existing climax and shade-tolerant species in Glacier NP, mainly because warmer conditions potentiate fire dynamics, including increased wildfire frequency and extent, which facilitates regeneration (Loehman et al., 2011).

State 2.0 Subalpine fir-Engelmann spruce/Rocky Mountain maple-thinleaf huckleberry/thimbleberry/wild Sarsaparilla-threeleaf foamflower-queencup bead lily

State 2 is different than State 1 in that western white pine no longer plays a significant role in the seral communities as it once did. The historic extent of western white pine in Glacier National Park was primarily along the western border. Western white pine has been dramatically reduced in numbers and area by the epidemics of white pine blister rust, western spruce budworm, and dramatic fire suppression. Therefore, climax species have been able to fill the seral role that western white pine held. As well, more forests are progressing to the climax or Reference Phase than historically when most forests were in the fire-maintained western white pine-dominated seral phase. Forests are now dominated by the shade-tolerant climax species subalpine fir and Engelmann spruce. While there is a tremendous effort to bolster the numbers of western white pine, it currently covers only 5 percent of its historic range.

Subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) are the dominant overstory species with co-occurring Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*). The main understory species are the medium sized shrub Rocky Mountain Maple, the mid height shrub Thinleaf huckleberry (*Vaccinium membranaceum*) with an understory of wild sarsaparilla, threelaf foamflower and queencup bead lily (*Clintonia uniflora*). Subalpine fir, Engelmann spruce, western larch, Douglas fir, western white pine, lodgepole pine are present in decreasing abundance. Queencup beadlily is the indicator species for all phases of this habitat type but other indicator species specifically for this moister phase include: American trailplant (*Adenocaulon bicolor*), bunchberry dogwood (*Cornus canadensis*), fragrant bedstraw (*Galium triflorum*), threeleaf foamflower (*Tiarella trifoliata*), twinflower (*Linnaea borealis*), Utah honeysuckle (*Lonicera utahensis*), Oregon boxleaf (*Paxistima myrsinites*), thimbleberry (*Rubus parviflorus*) and thinleaf huckleberry (*Vaccinium membranaceum*). These phases represent the wetter aspect of this habitat type. The rusty menziesia (*Menziesia ferruginea*) indicated type specifically represents areas that are cold and moist. It is more common on cool north and east exposures and has rusty menziesia and broadleaf arnica (*Arnica latifolia*) abundant. The other phase of this type (wild sarsaparilla) represents the wet and moist portion of the habitat type on bottomlands and at the lowest elevations of the ecological site. Wild sarsapirilla, Pacific oakfern (*Gymnocarpium disjunctum*) and common ladyfern (*Athyrium filix-femina*) are indicators of this phase and paper birch (*Betula papyrifera*) can occur as a seral tree species. Redosier dogwood (*Cornus sericea* ssp. sericea), Pacific yew (*Taxus brevifolia*), American trailplant, bunchberry dogwood, stiff clubmoss (*Lycopodium annotinum*) and groundcedar (*Lycopodium complanatum*) also occur frequently.

This ecological site is described as having Cool and Moist site conditions, high species diversity in the overstory including western larch, Douglas fir, Western white pine, Engelmann spruce, lodgepole pine, subalpine fir and Grand fir. Sites after stand replacement fires can be dominated by lodgepole pine. Sites are too cool for western redcedar and western hemlock and not cold enough for whitebark pine in any major way. The historic fire regime of these forests is one of low frequency (about 128 years) and high intensity, and therefore an increased chance of stand-replacing fire when it does occur due to moist site conditions, relatively high loadings of live and dead fuels and periodic summer drought. Stand replacement fires occurs in patches of anywhere from 200 to 2000 hectares (McDonald et al., 2000). 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-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. 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, or subalpine fir. Therefore, these species would dominate the maturing forest phase for longer. After a stand replacement fire at this stage with serotinous lodgepole pine present then lodgepole pine 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. Moderate or 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 have affected the Cryic/Udic Coniferous ecological site are the Starvation Creek fire in 1994, which burned 4,001 acres in Glacier NP and 7,202 total acres; the Wedge Canyon fire in 2003, which burned 30,314 acres in Glacier NP and 53,359 total acres; and the 1988 Red Bench fire, which burned 27,500 acres in Glacier NP and 36,037 total acres. All of those fires were caused by lightning. Also caused by lightning were the 2001 Moose fire, which burned 27,194 acres in Glacier NP and 70,605 total acres; the Harrison fire in 2003 burned 5,864 acres in Glacier NP; and the Rampage fire in 2003, which burned 21,630 in Glacier NP. The Robert fire in 2003 was caused by humans, and burned 39,384 acres in Glacier NP and 52,747 acres in total.

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 can commonly cause additional damage to stands following disease and pest disturbance. Subalpine fir is most commonly susceptible to Armilllaria and Annosus root disease, Pouch, Indian paint and red belt fungus 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 needle cast, snow blight and Fir-blueberry rust. Engelmann spruce is most commonly susceptible to Annosus and Schweintzii 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 and spruce canker and brown felt blight.

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 is aerial photography. These maps capture only moments in time though 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 (many very large polygons throughout the area) is defoliation by Western Spruce

Budworm. The defoliation was categorized as mostly low severity (equal to or less than 50% defoliation) and some high (with greater than 50% defoliation) on Abies species and the damage is contiguous or nearly continuous. The forest type was categorized as W. Fir-Spruce. There was also defoliation by Western Spruce budworm on Douglas fir, but to a much lesser degree. Larch casebearer, a defoliator of LAOC, and generalized needlecast of western larch was also found to a much lesser degree. Scattered small polygons 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 on ABIES spp., and Woolly adelgid on Abies spp., and general subalpine fir Mortality. Both of these would effect this ecological site and field notes corroborate these findings.
Community Phase 2.1: Subalpine fir-Engelmann spruce/Rocky Mountain maple-thinleaf huckleberry/thimbleberry/wild sarsaparilla-threeleaf foamflower-queencup beadlily
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. Overstory canopy cover ranges 40-60%. The understory is very lush, diverse and multi-storied (canopy cover dataset of 21 sites). Species occurring with high frequency of occurrence and high-moderate cover include the tall shrubs Greene's mountain ash, Utah honeysuckle and Rocky mountain maple. The next lower shrub layer includes rusty menziesia, thimbleberry, Oregon boxleaf, white spirea and thinleaf huckleberry. The lowest layer includes shrubs, grasses and forbs including heartleaf arnica, mountain brome, prince's plume, queencup beadlily, threepetal bedstraw, twinflower, western meadowrue, threeleaf foamflower and darkwoods violet. The foliar cover (dataset of 6 sites) is high (62%) and the ground cover is predominantly litter (woody litter, litter or duff) a total of 83%, of which duff is 66% and fairly high moss cover (25%). The community is multi-storied with tall trees ranging 14-31 m (580-over 1200 inches) tall. The understory is multi-layered with very tall shrubs ranging 2-2.5 m tall including Rocky mountain maple and Sitka alder. The tall shrub layer is 152 cm or 60 inches tall and includes Utah honeysuckle. The next layer is 76-101 cm (30-40 inches) tall including redosier dogwood, rusty menziesia, Scouler's willow, thimbleberry and yew. The next layer is 51-76 cm (20-30 inches) tall and includes ribes species, western meadowrue and mountain brome. Then there is a layer 25-51 cm (10-20 inches) tall including white spirea, wild sarsaparilla, thinleaf huckleberry and common snowberry. The lowest layer is comprised of forbs and grasses about 15-25 cm (6-10 inches) tall including creeping barberry, trailplant and diverse forbs. 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 community is multistoried as well with the mid-sized shrubs rocky mountain maple, thinleaf huckleberry and thimbleberry in clumps, and the herbaceous layer varied but with wild sarsaparilla, threeleaf foamflower and queencup bead lily apparent. This ecological site must have a presence of queencup bead lily and sometimes this is dominant. At this phase Armillaria root rot and defoliation by Western Spruce budworm can be a threat.

Community Phase Pathway 2.1A
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 2.1B
This pathway represents a major stand-replacing disturbance such as a high-intensity fire, large-scale wind event, or major insect infestation.

Forest Overstory Summary
Forest canopy: Canopy cover ranges from 40-50 percent
Average basal area: Total 300 ft2/acre
Site Index at 100 yrs: ABLA ranges 46-83 PIEN 59-85ranges
CMAI ABLA 80@95YRS PIEN 83@95YRS

Community Phase 2.2: Subalpine fir-Engelmann spruce (western larch-Douglas-fir)/Sitka alder/Rocky Mountain maple-rusty menziesia/wild sarsaparilla-twinflower
Structure: mosaic of mature overstory and regenerating openings
Community Phase 1.2 retains some areas that resemble Community Phase1.1, but it also contains moderate-sized (2-5 acres) openings. The canopy cover averages 60 percent. Subalpine fir and Engelmann spruce are both host to organisms causing root rot and heart rot, and with windthrow 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 2.2A
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 reinitiation—until they resemble the old-growth structure of the Reference Community.

Community Phase Pathway 2.2B
This pathway represents a major stand-replacing disturbance, such as a major insect outbreak or fire event, which leads to the stand initiation phase of forest development.

Community Phase 2.3
Structure: patchy clumps of regeneration, single story
Community Phase1.3 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 is generally 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, this species will dominate the area.

Community Phase Pathway 2.3A
This pathway represents continued growth over time with no further major disturbance.

Community Phase 2.4: Lodgepole pine (Douglas-fir-subalpine fir-Engelmann spruce)/Arnica species-beargrass
Structure: dense single story
Community Phase 2.4 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 and queencup beadlily. This community is more tolerant of Armillaria root rot due to forest stand composition, but is prone to defoliation by western spruce budworm on fir.
Community Phase Pathway 2.4A
This pathway represents continued growth over time with no further major disturbance.

Community Phase Pathway 2.4B
This pathway represents a major stand-replacing disturbance, such as a major insect outbreak or fire event, which leads to the stand initiation phase of forest development.

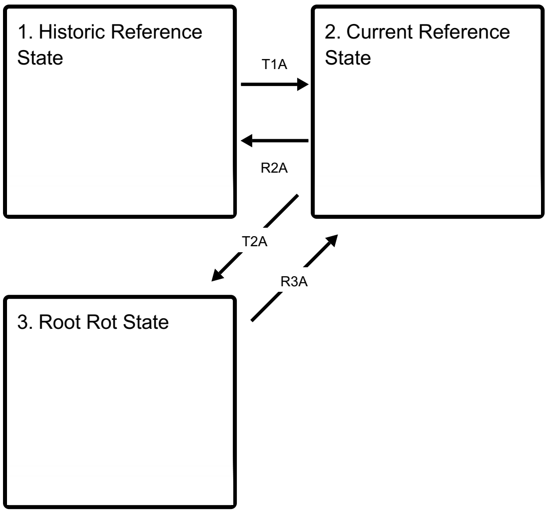
Community Phase 2.5: Subalpine fir-Engelmann spruce (western larch-Douglas-fir)/Sitka alder/Rocky Mountain maple-rusty menziesia/wild sarsaparilla-twinflower-queencup beadlily
Structure: single story with few small openings
Community Phase 2.5 is a maturing forest which is starting to differentiate vertically. The canopy cover ranges from averages 50 percent of mixed conifer species including subalpine fir, Engelmann spruce, Douglas fir and western larch. 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. The understory is lush, diverse and multi-storied. Species with high frequency of occurrence and moderate to high canopy cover (21 sites dataset) include the tall shrubs Sitka alder and Rocky mountain maple, the medium statured shrubs thinleaf huckleberry, thimbleberry and white spirea and Oregon boxleaf. The lowest layer includes queencup beadlily, threeleaf foamflower, western meadowrue, darkwoods violet, twinflower, heartleaf arnica, wild sarspirella and Pacific oakfern.
Community Phase Pathway 2.5A
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 2.5B
This pathway represents a major stand-replacing disturbance leading to the stand initiation phase of forest development.

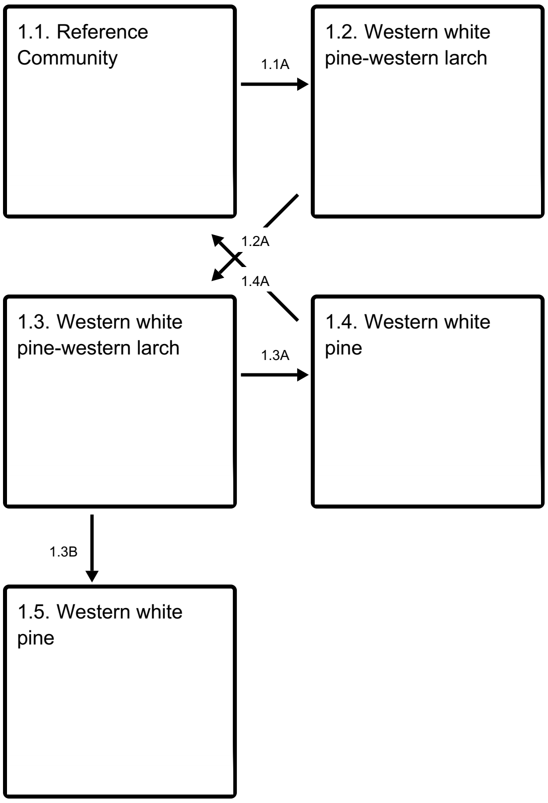
State 3.0
Another disease affecting this ecological site is root rot. Armillaria root disease is the most common root disease fungus in this region, especially prevalent west of the Continental Divide. It may be difficult to detect until it has killed enough trees to create large root disease pockets 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 you are managing, manage for pines, 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

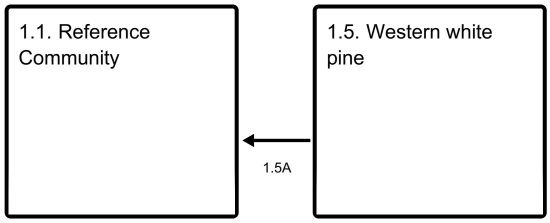
Ecosystem states



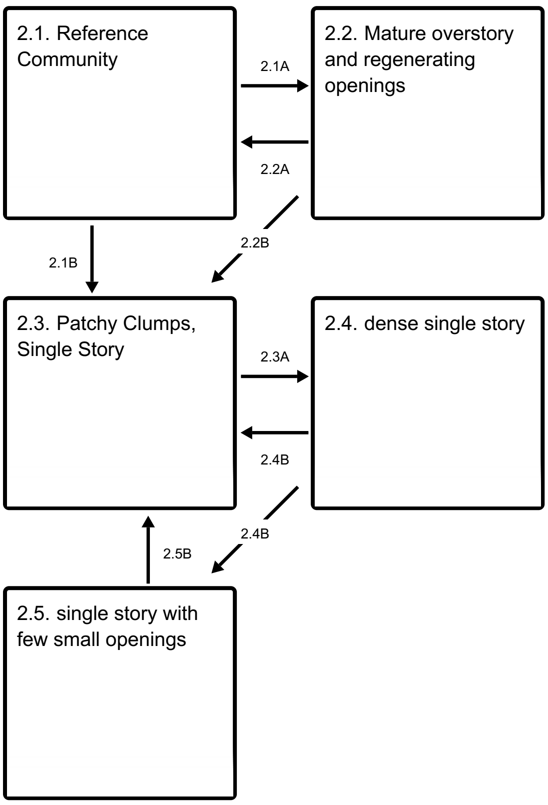
State 1 submodel, plant communities



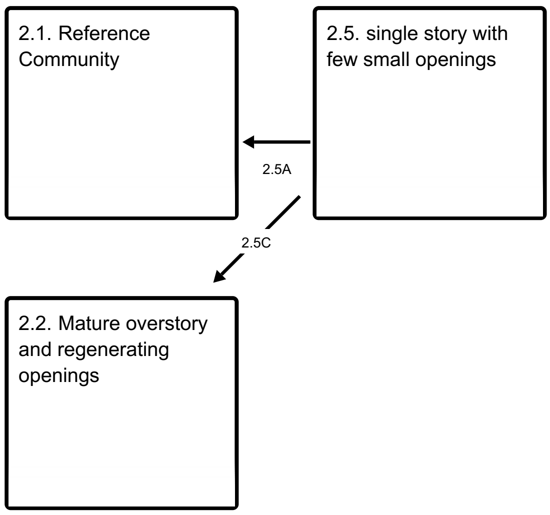
Communities 1 and 5 (additional pathways)



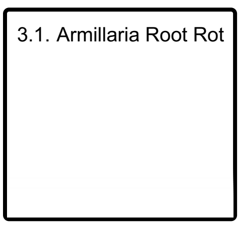
State 2 submodel, plant communities



Communities 1, 5 and 2 (additional pathways)



State 3 submodel, plant communities



State 1
Historic Reference State

Historically western white pine would have been within Flathead County, which encompasses the Flathead NF and in lower elevations, west of the continental divide in Glacier NP. Originally, western white pine covered 5 million acres in the Inland Northwest. Western white pine is incredibly productive for timber, with a very high growth rate, is tall and deep–rooted, and competes best on highly variable, high resource sites. As well, it is tolerant to the native root rot diseases and other native forest pests, is susceptible to Armillaria root disease only when young, and is vulnerable to mountain pine beetle largely at advanced ages (over 140 years). It also has the capability to thrive in a wide variety of sites and environments, which means it has high ecological flexibility. It is a long-living seral species that tolerated intense timber harvesting practices and severe fire disturbance by its ability to regenerate heavily on mineral soil and in full sunlight. Fire greatly influences the composition, structure, and function of vegetation across the landscape. Historically, it was mixed severity fire in between severe stand-replacing fires. Western larch and western white pine are long-lived, fire-adapted, shade-intolerant tree species that thrived historically. Also present in significant amounts particularly in young stands, but which declined through time due to effects of insects and pathogens, were the shorter-lived, shade-intolerant, fire-adapted tree species such as Douglas-fir and lodgepole pine. Shade-tolerant, fire-intolerant tree species such as western cedar, western hemlock, grand fir, Engelmann spruce, and subalpine fir were present but rarely survived long enough to dominate stands, except where the interval between fires was unusually long and where root disease was not severe. Prior to the 20th century, western white pine was a major component in forested ecosystems of the inland northwest U.S., but has been greatly reduced in distribution and abundance by white pine blister rust, mountain pine beetles, and anthropogenic fire exclusion (Tomback and Achuff, 2010). Western white pine has been replaced by Douglas-fir, grand fir and western hemlock. Douglas-fir and grand fir are susceptible to a greater variety of insect and disease problems and hemlock is more sensitive to drought and decay. More stands have also progressed to the climax species-dominated phase, which previously were rarely achieved due to the fire rotations and susceptibility of these species to disease and forest pests. In a study of the effects of pathogens and insects on forests within the Inland Empire found that, excluding fire, more than 90 percent of sample stands changed to a different cover type, structure stage, or both during a 40-year period that was coincident with the blister rust epidemic and fire suppression policy. Root pathogens, white pine blister rust, and bark beetles were the cause of most changes and this accelerated succession of western white pine, ponderosa pine, and lodgepole pine to later successional, more shade-tolerant species. The structure was reduced in stand density or prevented canopy closure. Grand fir, Douglas-fir, and subalpine fir were the predominant cover types at the end of the period, and were highly susceptible to root diseases, bark beetles, fire, and drought. It is estimated that there will be greater accumulations occurring in low-density mature and younger pole-sized stands that result from root disease and bark beetle-caused mortality (Byler and Hagle, 2000). These stands also are less productive in terms of timber. They are dominated by species with high nutrient demands where nutrient storage and cycling rates are increasingly depressed. This will likely lead to ever-increasing stress and destabilization by pests and diseases. Drought can further exacerbate the situation by stressing trees. The Inland Empire Tree Improvement Cooperative and the USFS have a breeding program for blister-resistant western white pine. A total of approximately 5 percent of the original acre range has been planted with rust-resistant stock. Currently, the modified stock shows about 60 percent resistance to blister rust. A study modeling the effects of climate change found that warming temperatures would favor increased abundance of western white pine over existing climax and shade-tolerant species in Glacier NP, mainly because warmer conditions potentiate fire dynamics, including increased wildfire frequency and extent, which facilitates regeneration (Loehman et al., 2011).

Community 1.1
Reference Community

Subalpine fir-Engelmann spruce overstory Minor western white pine-western larch Structure: Multistory with small gap dynamics Rare phase due to disturbance rotations

Community 1.2
Western white pine-western larch

Western white pine-western larch-(lodgepole pine) seedlings. Structure: patchy clumps, single story. Time spent in this phase: 1-50 years

Community 1.3
Western white pine-western larch

Western white pine-western larch-(subalpine fir-Engelmann spruce-Douglas fir) Structure: dense single story with diminished understory. Time spent in this phase: 50-140 years

Community 1.4
Western white pine

Western white pine-(subalpine fir-Engelmann spruce-Douglas fir). Structure: some vertical differentiation in stand. Time spent in this phase: 140 years- centuries

Community 1.5
Western white pine

Western white pine-(subalpine fir-Engelmann Douglas fir). Structure: Mature stand with patches. Time spent in this phase: 140 years- centuries

Pathway 1.1A
Community 1.1 to 1.2

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 1.2A
Community 1.2 to 1.3

Continued growth over time with no further major disturbance to dense single story pole sized stand.

Pathway 1.3A
Community 1.3 to 1.4

Continued growth over time with no further major disturbance to mature stand with all size classes.

Pathway 1.3B
Community 1.3 to 1.5

Continued growth over time with no further major disturbance with patches of regeneration.

Pathway 1.4A
Community 1.4 to 1.1

Continued growth over time with no further major disturbance with patches of regeneration.

Pathway 1.5A
Community 1.5 to 1.1

Continued growth over time with no further major disturbance with patches of regeneration.

State 2
Current Reference State

State 2 is different than State 1 in that western white pine no longer plays a significant role in the seral communities as it once did. The historic extent of western white pine in Glacier National Park was primarily along the western border. Western white pine has been dramatically reduced in numbers and area by the epidemics of white pine blister rust, western spruce budworm, and dramatic fire suppression. Therefore, climax species have been able to fill the seral role that western white pine held. As well, more forests are progressing to the climax or Reference

Phase than historically when most forests were in the fire-maintained western white pine-dominated seral phase. Forests are now dominated by the shade-tolerant climax species subalpine fir and Engelmann spruce. While there is a tremendous effort to bolster the numbers of western white pine, it currently covers only 5 percent of its historic range. Subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) are the dominant overstory species with co-occurring Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*). The main understory species are the medium sized shrub Rocky Mountain Maple, the mid height shrub Thinleaf huckleberry (*Vaccinium membranaceum*) with an understory of wild sarsaparilla, threelaf foamflower and queencup bead lily (*Clintonia uniflora*). Subalpine fir, Engelmann spruce, western larch, Douglas fir, western white pine, lodgepole pine are present in decreasing abundance. Queencup beadlily is the indicator species for all phases of this habitat type but other indicator species specifically for this moister phase include: American trailplant (*Adenocaulon bicolor*), bunchberry dogwood (*Cornus canadensis*), fragrant bedstraw (*Galium triflorum*), threeleaf foamflower (*Tiarella trifoliata*), twinflower (*Linnaea borealis*), Utah honeysuckle (*Lonicera utahensis*), Oregon boxleaf (*Paxistima myrsinites*), thimbleberry (*Rubus parviflorus*) and thinleaf huckleberry (*Vaccinium membranaceum*). These phases represent the wetter aspect of this habitat type. The rusty menziesia (*Menziesia ferruginea*) indicated type specifically represents areas that are cold and moist. It is more common on cool north and east exposures and has rusty menziesia and broadleaf arnica (*Arnica latifolia*) abundant. The other phase of this type (wild sarsaparilla) represents the wet and moist portion of the habitat type on bottomlands and at the lowest elevations of the ecological site. Wild sarsapirilla, Pacific oakfern (*Gymnocarpium disjunctum*) and common ladyfern (*Athyrium filix-femina*) are indicators of this phase and paper birch (*Betula papyrifera*) can occur as a seral tree species. Redosier dogwood (*Cornus sericea* ssp. sericea), Pacific yew (*Taxus brevifolia*), American trailplant, bunchberry dogwood, stiff clubmoss (*Lycopodium annotinum*) and groundcedar (*Lycopodium complanatum*) also occur frequently. This ecological site is described as having Cool and Moist site conditions, high species diversity in the overstory including western larch, Douglas fir, Western white pine, Engelmann spruce, lodgepole pine, subalpine fir and Grand fir. Sites after stand replacement fires can be dominated by lodgepole pine. Sites are too cool for western redcedar and western hemlock and not cold enough for whitebark pine in any major way. The historic fire regime of these forests is one of low frequency (about 128 years) and high intensity, and therefore an increased chance of stand-replacing fire when it does occur due to moist site conditions, relatively high loadings of live and dead fuels and periodic summer drought. Stand replacement fires occurs in patches of anywhere from 200 to 2000 hectares (McDonald et al., 2000). 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. 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Moderate or 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 have affected the Cryic/Udic Coniferous ecological site are the Starvation Creek fire in 1994, which burned 4,001 acres in Glacier NP and 7,202 total acres; the Wedge Canyon fire in 2003, which burned 30,314 acres in Glacier NP and 53,359 total acres; and the 1988 Red Bench fire, which burned 27,500 acres in Glacier NP and 36,037 total acres. All of those fires were caused by lightning. Also caused by lightning were the 2001 Moose fire, which burned 27,194 acres in Glacier NP and 70,605 total acres; the Harrison fire in 2003 burned 5,864 acres in Glacier NP; and the Rampage fire in 2003, which burned 21,630 in Glacier NP. The Robert fire in 2003 was caused by humans, and burned 39,384 acres in Glacier NP and 52,747 acres in total. 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 can commonly cause additional damage to stands following disease and pest disturbance. Subalpine fir is most commonly susceptible to Armilllaria and Annosus root disease, Pouch, Indian paint and red belt fungus 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 needle cast, snow blight and Fir-blueberry rust. Engelmann spruce is most commonly susceptible to Annosus and Schweintzii 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 and spruce canker and brown felt blight. 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 is aerial photography. These maps capture only moments in time though 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 (many very large polygons throughout the area) is defoliation by Western Spruce Budworm. The defoliation was categorized as mostly low severity (equal to or less than 50% defoliation) and some high (with greater than 50% defoliation) on Abies species and the damage is contiguous or nearly continuous. The forest type was categorized as W. Fir-Spruce. There was also defoliation by Western Spruce budworm on Douglas fir, but to a much lesser degree. Larch casebearer, a defoliator of LAOC, and generalized needlecast of western larch was also found to a much lesser degree. Scattered small polygons 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 on ABIES spp., and Woolly adelgid on Abies spp., and general subalpine fir Mortality. Both of these would effect this ecological site and field notes corroborate these findings.

Community 2.1
Reference Community

Subalpine fir-Engelmann spruce/Rocky Mountain maple-thinleaf huckleberry/thimbleberry/wild sarsaparilla-threeleaf foamflower-queencup beadlily 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. Overstory canopy cover ranges 40-60%. The understory is very lush, diverse and multi-storied (canopy cover dataset of 21 sites). Species occurring with high frequency of occurrence and high-moderate cover include the tall shrubs Greene’s mountain ash, Utah honeysuckle and Rocky mountain maple. The next lower shrub layer includes rusty menziesia, thimbleberry, Oregon boxleaf, white spirea and thinleaf huckleberry. The lowest layer includes shrubs, grasses and forbs including heartleaf arnica, mountain brome, prince’s plume, queencup beadlily, threepetal bedstraw, twinflower, western meadowrue, threeleaf foamflower and darkwoods violet. The foliar cover (dataset of 6 sites) is high (62%) and the ground cover is predominantly litter (woody litter, litter or duff) a total of 83%, of which duff is 66% and fairly high moss cover (25%). The community is multi-storied with tall trees ranging 14-31 m (580-over 1200 inches) tall. The understory is multi-layered with very tall shrubs ranging 2-2.5 m tall including Rocky mountain maple and Sitka alder. The tall shrub layer is 152 cm or 60 inches tall and includes Utah honeysuckle. The next layer is 76-101 cm (30-40 inches) tall including redosier dogwood, rusty menziesia, Scouler's willow, thimbleberry and yew. The next layer is 51-76 cm (20-30 inches) tall and includes ribes species, western meadowrue and mountain brome. Then there is a layer 25-51 cm (10-20 inches) tall including white spirea, wild sarsaparilla, thinleaf huckleberry and common snowberry. The lowest layer is comprised of forbs and grasses about 15-25 cm (6-10 inches) tall including creeping barberry, trailplant and diverse forbs. 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 community is multistoried as well with the mid-sized shrubs rocky mountain maple, thinleaf huckleberry and thimbleberry in clumps, and the herbaceous layer varied but with wild sarsaparilla, threeleaf foamflower and queencup bead lily apparent. This ecological site must have a presence of queencup bead lily and sometimes this is dominant. At this phase Armillaria root rot and defoliation by Western Spruce budworm can be a threat.

Community 2.2
Mature overstory and regenerating openings

Subalpine fir-Engelmann spruce (western larch-Douglas-fir)/Sitka alder/Rocky Mountain maple-rusty menziesia/wild sarsaparilla-twinflower Structure: mosaic of mature overstory and regenerating openings Community Phase 1.2 retains some areas that resemble Community Phase1.1, but it also contains moderate-sized (2-5 acres) openings. The canopy cover averages 60 percent. Subalpine fir and Engelmann spruce are both host to organisms causing root rot and heart rot, and with windthrow 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 2.3
Patchy Clumps, Single Story

Structure: patchy clumps of regeneration-single story Community Phase 2.3 is a forest in the stand initiation phase, possibly with scattered remnant mature trees; the composition of the seedlings depends on the natural seed sources available. The canopy cover is generally 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, it will dominate the area.

Community 2.4
dense single story

Lodgepole pine (Douglas-fir-subalpine fir-Engelmann spruce)/Arnica species-beargrass Structure: dense single story Community Phase 2.4 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 and queencup beadlily. This community is more tolerant of Armillaria root rot due to forest stand composition, but is prone to defoliation by western spruce budworm on fir.

Community 2.5
single story with few small openings

Subalpine fir-Engelmann spruce (western larch-Douglas-fir)/Sitka alder/Rocky Mountain maple-rusty menziesia/wild sarsaparilla-twinflower-queencup beadlily Structure: single story with few small openings Community Phase 2.5 is a maturing forest which is starting to differentiate vertically. The canopy cover ranges from averages 50 percent of mixed conifer species including subalpine fir, Engelmann spruce, Douglas fir and western larch. 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. The understory is lush, diverse and multi-storied. Species with high frequency of occurrence and moderate to high canopy cover (21 sites dataset) include the tall shrubs Sitka alder and Rocky mountain maple, the medium statured shrubs thinleaf huckleberry, thimbleberry and white spirea and Oregon boxleaf. The lowest layer includes queencup beadlily, threeleaf foamflower, western meadowrue, darkwoods violet, twinflower, heartleaf arnica, wild sarspirella and Pacific oakfern.

Pathway 2.1A
Community 2.1 to 2.2

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 2.1B
Community 2.1 to 2.3

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

Pathway 2.2A
Community 2.2 to 2.1

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 reinitiation—until they resemble the old-growth structure of the Reference Community.

Pathway 2.2B
Community 2.2 to 2.3

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

Pathway 2.3A
Community 2.3 to 2.4

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

Pathway 2.4B
Community 2.4 to 2.3

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

Pathway 2.4B
Community 2.4 to 2.5

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

Pathway 2.5A
Community 2.5 to 2.1

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 2.5C
Community 2.5 to 2.2

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

Pathway 2.5B
Community 2.5 to 2.3

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

State 3
Root Rot State

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 you are managing, manage for pines, 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 3.1
Armillaria Root Rot

Shrub dominated area Time=50+yrs

Transition T1A
State 1 to 2

Substantial loss of western white pine as a major seral tree species.

Restoration pathway R2A
State 2 to 1

Western white pine restored as a major seral tree species.

Transition T2A
State 2 to 3

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

Restoration pathway R3A
State 3 to 2

Conversion of the Armillaria root rot induced shrubland to forest, generally less susceptible seral tree species and eventually to climax tree species.

Additional community tables

Table 6. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
mountain brome	BRMA4	*Bromus marginatus*	–	–	0.5–15
pinegrass	CARU	*Calamagrostis rubescens*	–	–	0.5–15
blue wildrye	ELGL	*Elymus glaucus*	–	–	3
bluejoint	CACA4	*Calamagrostis canadensis*	–	–	0.5
Forb/Herb					
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–62.5
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	0.5–37.5
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–15
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	0.5–15
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	0.5–15
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	0.5–15
American trailplant	ADBI	*Adenocaulon bicolor*	–	–	0.5–15
wild sarsaparilla	ARNU2	*Aralia nudicaulis*	–	–	3–15
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–15
bunchberry dogwood	COCA13	*Cornus canadensis*	–	–	3–15
northern bedstraw	GABO2	*Galium boreale*	–	–	15
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0.5–15
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0.5–15
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–15
common beargrass	XETE	*Xerophyllum tenax*	–	–	3
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5–3
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5–3
twinflower	LIBO3	*Linnaea borealis*	–	–	0.5–3
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5–3
fireweed	CHAN9	*Chamerion angustifolium*	–	–	3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3

roughfruit fairybells	PRTR4	*Prosartes trachycarpa*	–	–	0.5–3
woodland strawberry	FRVE	*Fragaria vesca*	–	–	3
arnica	ARNIC	*Arnica*	–	–	3
broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	3
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	3
starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	–	3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5–3
bracted lousewort	PEBR	*Pedicularis bracteosa*	–	–	3
liverleaf wintergreen	PYAS	*Pyrola asarifolia*	–	–	0.5–3
greenflowered wintergreen	PYCH	*Pyrola chlorantha*	–	–	3
pinedrops	PTERO3	*Pterospora*	–	–	0.5
woodland pinedrops	PTAN2	*Pterospora andromedea*	–	–	0.5
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	0.5
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
stinging nettle	URDI	*Urtica dioica*	–	–	0.5
twin arnica	ARSO2	*Arnica sororia*	–	–	0.5
bluebell bellflower	CARO2	*Campanula rotundifolia*	–	–	0.5
Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	0.5
heartleaf twayblade	LICO6	*Listera cordata*	–	–	0.5
violet	VIOLA	*Viola*	–	–	0.5
Sitka valerian	VASI	*Valeriana sitchensis*	–	–	0.5
Fern/fern ally					
common ladyfern	ATFI	*Athyrium filix-femina*	–	–	3–97.5
western brackenfern	PTAQ	*Pteridium aquilinum*	–	–	0.5–15
Pacific oakfern	GYDI2	*Gymnocarpium disjunctum*	–	–	0.5–3
Shrub/Subshrub					
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	0.5–37.5
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	0.5–15
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–15
red elderberry	SARA2	*Sambucus racemosa*	–	–	0.5–15
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0.5–15
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	0.5–15
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	3
spreading dogbane	APAN2	*Apocynum androsaemifolium*	–	–	3
red baneberry	ACRU2	*Actaea rubra*	–	–	3
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–3
dwarf red blackberry	RUPU	*Rubus pubescens*	–	–	3
Woods' rose	ROWO	*Rosa woodsii*	–	–	3
rose	ROSA5	*Rosa*	–	–	0.5–3
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–3
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	0.5–3
common snowberry	SYAL	*Symphoricarpos albus*	–	–	0.5–3
creeping barberry	MARE11	*Mahonia repens*	–	–	0.5–3

prickly currant	RILA	*Ribes lacustre*	–	–	0.5–3
sticky currant	RIVI3	*Ribes viscosissimum*	–	–	0.5
alderleaf buckthorn	RHAL	*Rhamnus alnifolia*	–	–	0.5
devilsclub	OPHO	*Oplopanax horridus*	–	–	0.5
Tree					
Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	0.5–15
paper birch	BEPA	*Betula papyrifera*	–	–	0.5–3
western redcedar	THPL	*Thuja plicata*	–	–	3
Pacific yew	TABR2	*Taxus brevifolia*	–	–	0.5
Nonvascular					
stiff clubmoss	LYAN2	*Lycopodium annotinum*	–	–	3

Table 7. Community 2.5 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
woodrush	LUZUL	*Luzula*	–	–	37.5
mountain brome	BRMA4	*Bromus marginatus*	–	–	0.5–15
pinegrass	CARU	*Calamagrostis rubescens*	–	–	3
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	3
Forb/Herb					
wild sarsaparilla	ARNU2	*Aralia nudicaulis*	–	–	0.5–37.5
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	3–15
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–15
twinflower	LIBO3	*Linnaea borealis*	–	–	3–15
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	15
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5–15
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	3–15
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–15
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	0.5–15
common beargrass	XETE	*Xerophyllum tenax*	–	–	3–15
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–3
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	0.5–3
stinging nettle	URDI	*Urtica dioica*	–	–	3
Sitka valerian	VASI	*Valeriana sitchensis*	–	–	3
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5–3
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	3
miterwort	MITEL	*Mitella*	–	–	3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5–3
Scouler's woollyweed	HISC2	*Hieracium scouleri*	–	–	0.5–3
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0.5–3
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5–3
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	0.5–3
starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	–	0.5–3

western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	3
aster	ASTER	*Aster*	–	–	0.5–3
common yarrow	ACMI2	*Achillea millefolium*	–	–	3
American trailplant	ADBI	*Adenocaulon bicolor*	–	–	0.5–3
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5
northwestern twayblade	LICA10	*Listera caurina*	–	–	0.5
yellow avalanche-lily	ERGR9	*Erythronium grandiflorum*	–	–	0.5
woodland strawberry	FRVE	*Fragaria vesca*	–	–	0.5
northern bedstraw	GABO2	*Galium boreale*	–	–	0.5
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5
liverleaf wintergreen	PYAS	*Pyrola asarifolia*	–	–	0.5
bracted lousewort	PEBR	*Pedicularis bracteosa*	–	–	0.5
lesser roundleaved orchid	PLOR4	*Platanthera orbiculata*	–	–	0.5
hookedspur violet	VIAD	*Viola adunca*	–	–	0.5
pioneer violet	VIGL	*Viola glabella*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
Pacific trillium	TROV2	*Trillium ovatum*	–	–	0.5
Fern/fern ally					
Pacific oakfern	GYDI2	*Gymnocarpium disjunctum*	–	–	0.5–37.5
western brackenfern	PTAQ	*Pteridium aquilinum*	–	–	3–15
stiff clubmoss	LYAN2	*Lycopodium annotinum*	–	–	3
common ladyfern	ATFI	*Athyrium filix-femina*	–	–	3
horsetail	EQUIS	*Equisetum*	–	–	0.5
Shrub/Subshrub					
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	3–62.5
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	3–37.5
bunchberry dogwood	COCA13	*Cornus canadensis*	–	–	3–15
twinberry honeysuckle	LOIN5	*Lonicera involucrata*	–	–	3–15
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–15
thimbleberry	RUPA	*Rubus parviflorus*	–	–	3–15
red elderberry	SARA2	*Sambucus racemosa*	–	–	15
prickly currant	RILA	*Ribes lacustre*	–	–	0.5–15
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–15
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	3–15
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–15
whortleberry	VAMY2	*Vaccinium myrtillus*	–	–	3
russet buffaloberry	SHCA	*Shepherdia canadensis*	–	–	3
common snowberry	SYAL	*Symphoricarpos albus*	–	–	0.5–3
Woods' rose	ROWO	*Rosa woodsii*	–	–	3
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	0.5–3
devilsclub	OPHO	*Oplopanax horridus*	–	–	3
creeping barberry	MARE11	*Mahonia repens*	–	–	0.5–3
redosier dogwood	COSES	*Cornus sericea ssp. sericea*	–	–	3

redosier dogwood	COSES	*Cornus sericea ssp. sericea*	–	–	3
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	3
red baneberry	ACRU2	*Actaea rubra*	–	–	0.5–3
willow	SALIX	*Salix*	–	–	3
rose	ROSA5	*Rosa*	–	–	0.5
Tree					
Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	0.5–37.5
Pacific yew	TABR2	*Taxus brevifolia*	–	–	15
black cottonwood	POBAT	*Populus balsamifera ssp. trichocarpa*	–	0–11.9	3
paper birch	BEPA	*Betula papyrifera*	–	–	0.5–3
Nonvascular					
Moss	2MOSS	*Moss*	–	–	3–85

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Approval

Kirt Walstad, 9/09/2023

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:**