USDA Natural Resources Conservation Service

Ecological site F043AX951MT
Lower Subalpine Cool Dry Coniferous subalpine fir- Engelmann spruce/ Sitka alder/ thinleaf huckleberry/ common beargrass

Last updated: 5/03/2024
Accessed: 05/18/2024

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 LRU 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/CLUN2 which is further divided into phases with the relevant phases to this ecological site being beargrass. 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. It also relates to the National Park Service vegetation map, NatureServe classification of *Abies lasiocarpa-Picea engelmannii*/*Clintonia uniflora-Xerophyllum tenax* Forest CEGL005892.

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 moderately drier aspect of this grouping, and is indicated by beargrass (*Xerophyllum tenax*) and queen cup bead lily (*Clintonia uniflora*) as the indicator understory species. This ecological site is in cool, moderately dry mid-elevations that span the lower subalpine zone. It is found primarily on lateral moraine and glacial valley wall landforms, on back or footslope positions, at elevations ranging 1,000 to 2,100 meters (3,280-6,890 feet), on all aspects and on moderate to steep slopes ranging 10-35 percent. 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 tall shrub Sitka alder (*Alnus viridis*), the mid-height shrub thinleaf huckleberry (*Vaccinium membranaceum*), with an understory of beargrass (*Xerophyllum tenax*) and queencup beadlily (*Clintonia uniflora*). Soils associated with this Ecological Site are very deep and well drained. These soils have developed in glacial till or colluvium

parent materials derived from metasedimentary rock that typically have varying amounts influence of volcanic ash in the soil surface layers. The degree of volcanic ash influence on these soils depends on the location within the local landscape. Soils on steeper south-facing aspects tend to have less volcanic ash or ash that is more mixed with subsurface materials, while north-facing aspects on steep slopes tend to have greater thicknesses of volcanic ash. Accumulation zones such as footslopes and toeslopes, with lower slope gradients also tend to more consistently have a presence of and greater thickness of volcanic ash. The dominant taxonomic soil order associated with these soils is Inceptisols with Andic subgroups indicating that there is 18 to 37 centimeters (7-14.5 inches) of volcanic ash. Other soil orders are Alfisols in more stable positions and Andisols in concave accumulation zones where volcanic ash thickness is greater than 37 centimeters (14.5 inches).

Associated sites

F043AX952MT	**Lower Subalpine Cool Moist Coniferous subalpine fir-Engelmann spruce/Rocky Mountain maple-thinleaf huckleberry/thimbleberry**
F043AX956MT	**Subalpine Coniferous Cool Moderately Dry subalpine fir (Abies lasiocarpa) / Engelmann spruce (Picea engelmannii)**
R043AX966MT	**Montane Loamy Outwash Terrace Richardson's needlegrass (Achnatherum richardsonii)**
R043AX973MT	**Montane Fen woollyfruit sedge (Carex lasiocarpa)**
R043AX974MT	**Montane Swale Drummond's willow (Salix drummondii)-alderleaf buckthorn (Rhamnus alnifolia)**
R043AX961MT	**Subalpine Avalanche Rocky Mountain maple-Redosier dogwood Acer glabrum-Conus sericea ssp. sericea-Amelanchier alnifolia** The 43A Subalpine Active Avalanche ecological site is found in avalanche chutes and associated runout zones at elevations ranging 1,200-2,100m. (3,935-6,890 ft.) on slopes from 15% to 60% on all aspects.43A Subalpine Active Avalanche ecological site has very deep soils with high vegetative production, resulting in an abundance of roots and organic matter accumulation. These soils are dark and fertile due to the regular and continual avalanche disturbances. Pulses of additional water in the form of greater snowpack thicknesses and entrained debris provide inputs which contribute to maintaining the high productivity on this site. Soils associated with this site are very deep and well drained, and are classified in the Mollisols taxonomic soil order due to the presence of a thick dark surface with high base saturation called a mollic epipedon. The 43A Subalpine Active Avalanche ecological site has a reference vegetation community of Rocky mountain maple, redosier dogwood and common snowberry shrubs with an understory of thimbleberry, fragrant bedstraw, common cowparsnip and blue wildrye.
R043AX968MT	**Montane Stable Colluvial Slope Saskatoon serviceberry-common snowberry/Sitka alder/ Rocky mountain maple/thimbleberry/mountain brome-Geyer's sedge** The 43A Montane Stable Colluvial Slope ecological site is found on steep slopes (35-60 percent), on back, foot and backslope positions on glacial valley wall landforms at elevations ranging from 1,150-2,100 meters (3,770-6,890 feet). You know you have crossed from the subalpine coniferous dry to the Montane Stable colluvial slope ES when slopes become greater than 35%.The 43A Montane Steep Stable Colluvial Slope has soils that are very deep and well drained soils from till or colluvium from metasedimentary rock parent material. There is a high volume of fragments (50 to 67 percent by volume) within the soil profile. The predominant texture in the surface is very gravelly sandy loam and the subsurface is sandy skeletal. There are no redoximorphic features in the soil and there is rarely an argillic or mollic layer. There is a thin organic layer, usually less than 5cm. (2in.) thick. The 43A Montane Steep Stable Colluvial Slope ecological site is found on steep slopes with vegetation cover ranging from impenetrable shrubs to open canopy of medium statured shrubs with lush understory of grass and forb species. Steep sites on valley walls. The thick vegetative growth contributes to the dark surface horizon colors in these soils. The reference vegetation community is Saskatoon serviceberry (Amelancheir alnifolia), common snowberry (Symphoricarpos albus), Sitka alder (Alnus viridis ssp. sinuata), Rocky mountain maple (Acer glabrum), thimbleberry (Rubus parviflorus), mountain brome (Bromus marginatus) and Geyer's sedge (Carex geyeri).

F043AX959MT	**Montane Warm Dry Coniferous Douglas fir/white spirea-common snowberry/pinegrass** Comparison of associated sites physiography with 43A Lower Subalpine Coniferous Cool Moderately Dry Site The 43A Montane Warm Dry Coniferous, Douglas fir/common snowberry site is found west of the Continental Divide in well drained mountain slopes and valleys that span the lower elevations, and at higher elevations on southern and western aspects. At lower elevations it is bordered by ponderosa pine sites or grasslands, and at higher elevations by subalpine fir sites. It occurs primarily on ground moraines, lateral moraines and outwash terrace landforms, on backslope positions, on moderate to steep slopes ranging 5-35%, at elevations ranging 1,000 to 1,900 meters (3,280-6,230 feet). 43A Montane Warm Dry Coniferous, Douglas fir/common snowberry: Soils associated with this ecological site are very deep, well drained and derived from glacial till or outwash. Soil textures typically are loamy, but can have skeletal subsurface horizons that have a high amount of rock fragments (>35% by volume) and relatively lower water-holding capacity. They are typically classified as Inceptisols or Alfisols. This associated site differs from the Lower Subalpine Coniferous Cool Moderately Dry due to a higher % of rock fragments and relatively lower water-holding capacity.The 43A Montane Warm Dry Coniferous, Douglas fir/common snowberry has a reference vegetation community of Douglas fir overstory with an understory of white spirea, common snowberry, pinegrass and heartleaf arnica. The 43B Montane Deciduous Clayey Outwash Terrace, ecological site has a reference vegetation community of Quaking aspen overstory with an understory of Saskatoon serviceberry, common snowberry, common cowparsnip-western sweetroot and mountain brome.

Table 1. Dominant plant species

Tree	(1) *Abies lasiocarpa* (2) *Picea engelmannii*
Shrub	(1) *Vaccinium membranaceum* (2) *Alnus viridis ssp. sinuata*
Herbaceous	(1) *Xerophyllum tenax* (2) *Clintonia uniflora*

Physiographic features

This site is found in cool, moderately dry mid-elevations that span the lower subalpine areas. It is found primarily on lateral moraine and glacial valley wall landforms, on back or footslope positions, at elevations ranging 1,000 to 2,100 meters (3,280-6,890 feet), on all aspects and on moderate to steep slopes ranging 10-35 percent.

Figure 1.

Table 2. Representative physiographic features

Landforms	(1) Mountains > Lateral moraine (2) Mountains > Mountain slope (3) Mountains > Ground moraine (4) Mountains > Glacial-valley wall
Elevation	1,000–2,100 m

Slope	10–35%
Aspect	W, NW, N, NE, E, SE, S, SW

Table 3. Representative physiographic features (actual ranges)

Elevation	Not specified
Slope	10–60%

Climatic features

This ecological site is found in the cryic soil temperature regime and the udic soil moisture regime. Cryic soils have average annual temperatures of less than 8 degrees C, with less than 5 degrees C difference from winter to summer. The udic soil moisture regime denotes that the rooting zone is usually moist throughout the winter and the majority of summer. This site is found on the west side of the Continental Divide and has more maritime weather influences.
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

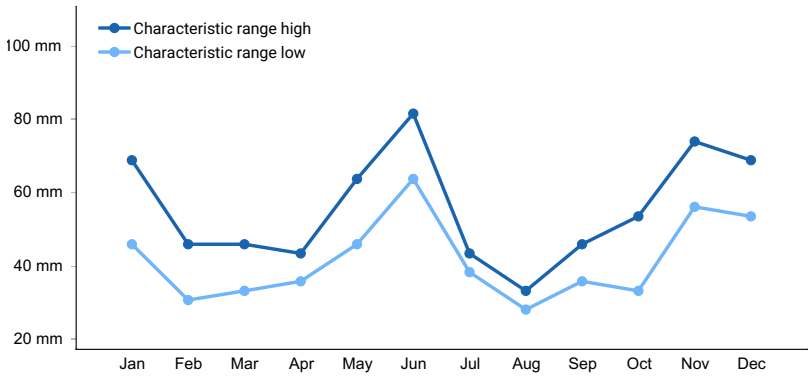


Figure 2. Monthly precipitation range

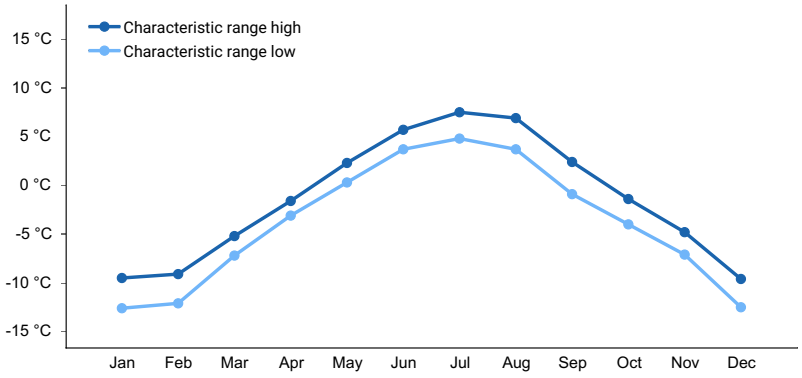


Figure 3. Monthly minimum temperature range

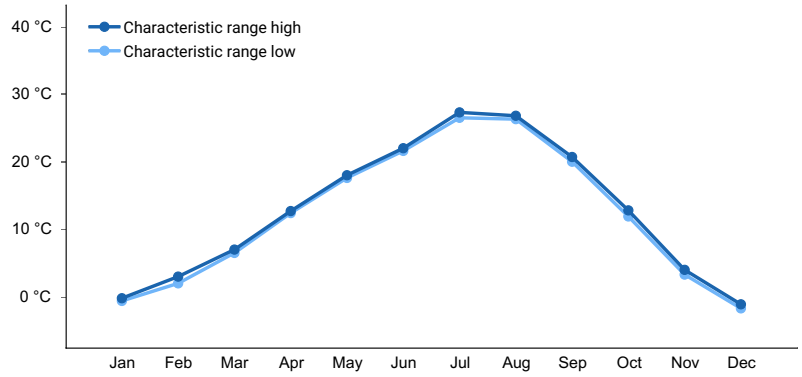


Figure 4. Monthly maximum temperature range

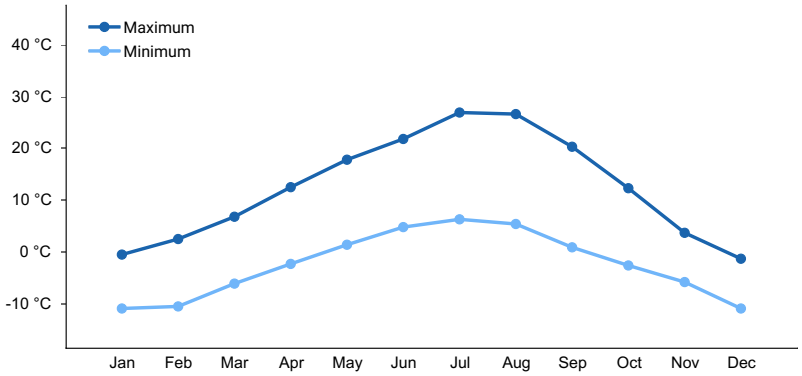


Figure 5. Monthly average minimum and maximum temperature

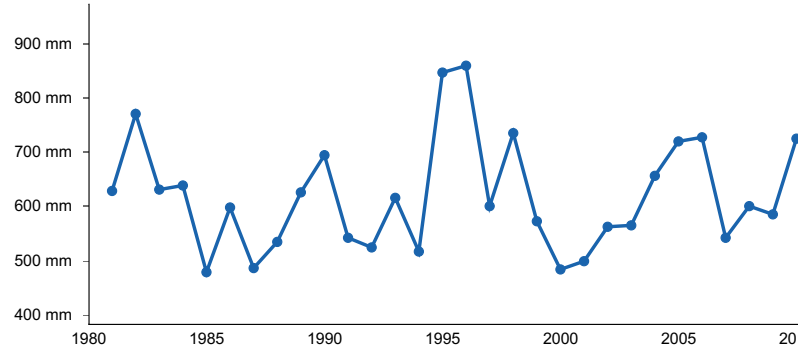


Figure 6. Annual precipitation pattern

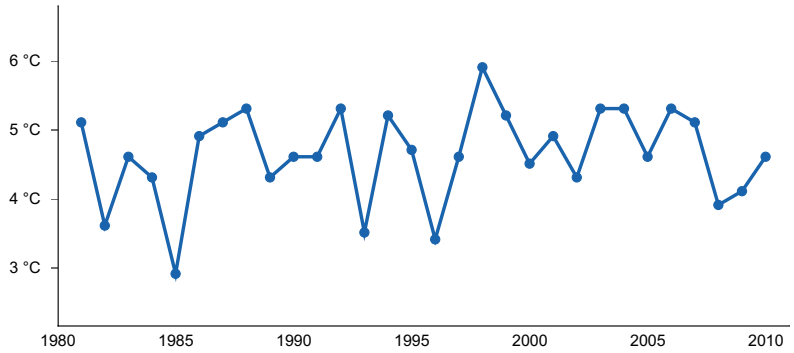


Figure 7. Annual average temperature pattern

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 and well drained. These soils have developed in glacial till or colluvium parent materials derived from metasedimentary rock that typically have varying amounts of influence of volcanic ash in the soil surface layers. The degree of volcanic ash influence on these soils depends on the location within the local landscape. Soils on steeper south-facing aspects tend to have less volcanic ash or ash that is more mixed with subsurface materials, while north-facing aspects on steep slopes tend to have greater thicknesses of volcanic ash. Accumulation zones such as footslopes and toeslopes, with lower slope gradients also tend to more consistently have a presence of and greater thickness of volcanic ash. The dominant taxonomic soil order associated with these soils is Inceptisols with Andic subgroups indicating that there is 18 to 37 centimeters (7-14.5 inches) of volcanic ash. Other soil orders are Alfisols in more stable positions and Andisols in concave accumulation zones where volcanic ash thickness is greater than 37 centimeters (14.5 inches). Diagnostic features include ochric epipedon, andic soil properties, cambic horizon, and less commonly argillic horizons (Soil Survey Staff, 2015). Under a closed canopy of tree cover there is typically a thin surface layer of organic material, usually less than 7cm. (3in.) 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
Ericson Fine-loamy, mixed, superactive Typic Haplocryalfs
Kegsprings Loamy-skeletal, mixed, superactive Typic Haplocryepts
Kintla Medial-skeletal over loamy-skeletal, amorphic over isotic Typic Haplocryands
Leighcan Loamy-skeletal, mixed, superactive Typic Dystrocryepts
Mohaggin Loamy-skeletal, mixed, superactive Andic Dystrocryepts
Pippin Sandy-skeletal, mixed Typic Haplocryepts
Risingwolf Loamy-skeletal, isotic Andic Haplocryepts
Sherlock Loamy-skeletal, isotic Andic Haplocryalfs
Watsondraw Loamy-skeletal, mixed, superactive Eutric Haplocryalfs
Worock Loamy-skeletal, mixed, superactive Eutric Haplocryalfs

Figure 8.

Table 5. Representative soil features

Parent material	(1) Volcanic ash–metasedimentary rock (2) Till–metasedimentary rock (3) Colluvium–metasedimentary rock
Surface texture	(1) Very gravelly, ashy loam
Family particle size	(1) Loamy-skeletal
Drainage class	Well 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 (3.6-14.7cm)	Not specified
Soil reaction (1:1 water) (14.7-17.8cm)	Not specified

Ecological dynamics

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 moderately drier aspect of this grouping, and is indicated by beargrass (*Xerophyllum tenax*) as the indicator species. This ecological site is in cool, moderately dry 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
Various management strategies can be employed for the lower subalpine coniferous cool moderately dry ecological site, depending upon the ownership of the particular land and which value is prioritized. The management of the forest determines the composition of the stand and the amount of fuel loading. A stand will be managed differently and look differently if it is managed for timber or ecological services like water quality and quantity, old growth, or endangered species. If a stand is managed for timber, it may be missing certain attributes necessary for lynx habitat. If a stand is managed for lynx habitat, it may have increased fuels and therefore an increased risk of wildfires.

The USFS Habitat Type guide states that the basal area on the West side of the Continental Divide for the habitat type subalpine fir/queencup beadlily is 248+/- ft2 per acre and site index at 50 years for Picea is 66 +/- 6 feet, and

for Abies it is 59+/-6 feet. Timber production on these sites vary from low to very high, and are important for water production. The drier phases are less productive for timber and water than the wetter phases. Timber production is lowest in the beargrass phase of the Cryic/Udic Coniferous ecological site, and site preparation is needed for prompt seedling establishment in this driest phase. The management of USFS lands is encompassed in the management plan for each National Forest. The management plan for the Flathead NF also has an Appendix B that gives specific management guidelines for habitat types (which relate to our forested ecological sites) found on the forest in relation to current and historic data on forest conditions (Flathead NF Plan, 2001 and Appendix B). Another guiding USFS document is the Green et al. document (2005) which defines “Old Growth” forest for the northern Rocky Mountains. This document provides an ecologically-based classification of old growth based on forest stand attributes including numbers of large trees, snags, downed logs, structural canopy layers, canopy cover, age, and basal area. While this document finds that the bulk of the pre-settlement upland old growth in the northern Rockies was in the lower elevation, ground fire-maintained ponderosa pine/western larch/Douglas-fir types (Losensky, 1992), it does not mean that other types were not common or not important. This could apply to some of the areas of this ecological site.

The USFS Habitat Type subalpine fir/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.

The subalpine fir/ queencup beadlily habitat type is common, but colder types dominate the Flathead NF. This type 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 percent survival against white pine blister rust. Historically, this habitat type was managed using traditional even-age strategies on the Flathead NF. Starting sixty years ago, they regenerated very many of this habitat type. Management also is needed to employ intense methods to allow for scarification of the soil, which is a regeneration requirement of western larch. These methods include harvesting using skid trails, and prescribed burns for site preparation, but the 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 Wilderness Urban Interface (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, 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 subalpine fir, it might fall within the snowshoe hare screen for the Lynx Amendment and will be managed for lynx habitat. 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

Western white pine (*Pinus monticola*)/subalpine fir (*Abies lasiocarpa*)-Engelmann spruce (*Picea engelmannii*)/thinleaf huckleberry (*Vaccinium membranaceum*)/common beargrass (*Xerophyllum tenax*)-queencup beadlily (*Clintonia uniflora*)

Historically, western white pine would have been within Flathead County, Montana, 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, 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. Western white pine is susceptible to Armillaria root disease only when young, and 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, meaning it has high ecological flexibility. Western white pine 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. Moisture and soil temperature determine seed germination onset. Fire greatly influences the composition, structure, and function of vegetation

across the landscape. Historically, this ecological site had mixed severity fire in between severe stand-replacement fires. Western larch and western white pine are long-lived, fire-adapted, shade-intolerant tree species that historically thrived. Also present in significant amounts, particularly in young stands, but declined through time due to the effects of insects and pathogens, were 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 in areas 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. A study of pathogens and insects effects 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 beetle were the causes 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, and 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 was 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/Sitka alder/Thinleaf huckleberry/beargrass-queencup beadlily
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 and western spruce budworm, and by 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.

Currently, 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 tall shrub Sitka alder (*Alnus viridis*), the mid-height shrub thinleaf huckleberry (*Vaccinium membranaceum*), with an understory of beargrass (*Xerophyllum tenax*) and queencup beadlily (*Clintonia uniflora*). The queencup beadlily phase specifically represents the middle or average environmental conditions, and is the most common type. Subalpine fir, Engelmann spruce, western larch, Douglas-fir, and lodgepole pine are present in decreasing abundance. Queencup beadlily is the indicator species for all phases of this habitat type, but other commonly-occurring species specifically for this phase include fragrant bedstraw (*Galium triflorum*), threeleaf foamflower (*Tiarella trifoliata*), Oregon boxleaf (*Paxistima myrsinites*), thimbleberry (*Rubus parviflorus*), and thinleaf huckleberry (*Vaccinium membranaceum*). Other frequently occuring species for this ecologcial site include Rocky mountain maple (*Acer glabrum*), Sitka alder (*Alnus viridis* sitchensis), white spirea (Spirea betulafolia), heartleaf arnica (*Arnica cordifolia*), mountain brome (*Bromus marginatus*), western meadowrue (*Thalictrum occidentale*) and beargrass. The other phase of this type (beargrass) represents the dry, colder portion

of the habitat type on well drained sites, i.e. south- and west-facing slopes. It has the same indicator species in the understory, but is dominated by beargrass.

This ecological site is described as having cool and moderately dry site conditions and 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 hemlock and western redcedar, and not cold enough for whitebark pine. The historic fire regime of these forests is one of low frequency (about 128 years) and high intensity, and therefore has an increased chance of stand-replacement fire when it does occur, due to site conditions, relatively high loadings of live and dead fuels, and periodic summer drought. The drier phases of this habitat type described in this site may have more frequent fires of lower to moderate severity than the moister phases. Stand-replacement fires occur in patches of 200 to 2,000 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-replacement fire in the mature forest or Reference phase would result in the stand initiation phase, with species composition of seedlings varying with site conditions. Moderate fires (or mixed severity fires) in the competitive exclusion phase would favor the more fire-resistant Douglas-fir and western larch, or western white pine over lodgepole pine, Engelmann spruce, and subalpine fir. Therefore, these species would dominate the maturing forest phase for a longer period of time. After a stand-replacement fire at this stage with serotinous lodgepole pine present, the seedlings will 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 the Douglas-fir, leaving the site to be regenerated by 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 it will continue into the Reference phase. Significant fires that have occurred on the west side of the Continental Divide that affected the Cryic/Udic Coniferous ecological site are the 1994 Starvation Creek fire, caused by lightning, which burned 7,202 total acres, 4,001 of which were in Glacier NP, and the 2003 Wedge Canyon fire, also caused by lightning, which burned 53,359 total acres, 30,314 of which were in Glacier NP. The 1988 Red Bench fire was caused by lightning and burned 36037 total acres, 27,500 of which were in Glacier NP. The lightning-caused Moose fire in 2001 burned 27,194 acres in Glacier NP, and 70605 total acres. The 2003 Robert fire was caused by humans and burned 52,747 total acres, 39,384 acres of which were in Glacier NP. The Harrison fire in 2003 burned 5,864 acres in Glacier NP, caused by lighting. Finally, the 2003 Rampage fire, caused by lightning, burned 21,630 in Glacier NP.

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

Aerial photography is a good tool to use to discern the level of insect and disease and the damage patterns and whether these are at endemic or epidemic levels. These maps capture only moments in time and infestations grow and move from location to location following their preferred habitat, so repeated photography can be necessary. Specifically, for the northern region, the USFS Stand Health map (Aerial Detection Survey maps, 2014) shows that the major impact to this area is defoliation by western spruce budworm. The defoliation was categorized as mostly of low severity (equal to or less than 50 percent defoliation) and some of high severity (with greater than 50 percent defoliation) on Abies species, and the damage is contiguous or nearly continuous. The forest type was categorized as western Fir-Spruce type. There also was defoliation by western spruce budworm on Douglas-fir, but to a much

lesser degree. Larch casebearer, a defoliator of western larch, and generalized needlecast of western larch also was found to a much lesser degree. Scattered small areas of damage were found throughout the region, including mortality from mountain pine beetle on lodgepole pine, Douglas-fir beetle on Douglas-fir, spruce beetle on Engelmann spruce, fir engravers and Woolly adelgid on ABIES spp., and general subalpine fir mortality. Any of these would affect the Cryic/Udic Coniferous ecological site, and field notes corroborate these findings.
Community Phase 2.1
Structure: Multistory with small gap dynamics

The overstory is dominated by subalpine fir and Engelmann spruce, with small gap dynamics in which small numbers of trees are dead and conifer regeneration is infilling. The overstory canopy cover averages 40-50 percent. The understory is multistoried with tall shrubs Sitka alder, Rocky mountain maple with a lower shrub layer including thinleaf huckleberry and white spirea. The lower layer includes shrubs, grasses and forbs with the most frequently occurring including beargrass, threeleaf foamflower, western meadowrue, thimbleberry, Oregon boxleaf, heartleaf arnica, mountain brome and queencup beadlily (18 sites canopy cover data). The foliar cover (6 sites dataset) is high at this community phase (68 percent), with very high cover of total litter on the ground (93% percent, 87% is duff), moderate cover of moss (8 percent) and very low cover of gravel and bare soil (4%). This community has an overstory of trees ranging from 80 to 100 feet tall. The understory is multi-layered with the tall layer growing 30-40 inches tall (Utah honeysuckle, Sitka alder, Rocky Mountain maple, red baneberry), the next layer is 20-30 inches tall (common snowberry, serviceberry, thinleaf huckleberry), and the lower layer is 10-20 inches tall (white spirea, rose species, beargrass, thimbleberry), the lowest layer is below 10 inches (pinegrass, queencup beadlily, Geyer's sedge, prince's plume, heartleaf arnica, darkwoods violet). 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 tall Sitka alder in clumps, the medium-height thinleaf huckleberry throughout, and the herbaceous layer varied, but with the beargrass phase type dominated by that species. This ecological site must have a presence of queencup beadlily, 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-replacement disturbance such as a high-intensity fire, large-scale wind event, or major insect infestation
Community Phase 2.2: Subalpine fir-Engelmann spruce (western larch-lodgepole pine)/Sitka alder/thinleaf huckleberry/beargrass-queencup beadlily

Structure: Mosaic of mature overstory and regenerating openings

Community Phase 2.2 retains some areas that resemble Community Phase 1.1, but also contains moderate-sized (2-5 acres) openings. The canopy cover ranges from 50-60 percent. Subalpine fir and Engelmann spruce are both hosts to organisms causing root rot and heart rot, and combined with windthrow large pockets of overstory mortality may occur. These areas may take decades to become reforested, resulting in either patches of shrubs or seral species such as western larch and lodgepole pine. 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, understory reinitiation—until they resemble the old-growth structure of the Reference Community.

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

Community Phase 2.3: Thimbleberry/Arnica species-western showy aster/mountain brome

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 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, then this species will dominate the area. Queencup beadlily is present at this community phase. Species occurring with high frequency include fireweed, queencup beadlily, thimbleberry, white spirea, western meadowrue and beargrass. Fireweed, western showy aster and snowbush ceanothus can have infrequent, high canopy cover.
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)/white spirea-thinleaf huckleberry/pinegrass-beargrass

Structure: Dense single story
Community Phase 2.4 is a forest in the competitive exclusion phase, possibly with scattered remnant mature trees; competition is increased among individual trees 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 subject to defoliation by western spruce budworm on fir. The understory is multistructured with the tall shrub layer including serviceberry and Greene’s mountain ash. The lower shrub layer includes white spirea, thinleaf huckleberry and Rocky mountain maple and thimbleberry. The lowest layer includes queencup beadlily, beargrass, heartleaf arnica and pinegrass (14 sites of canopy cover data).
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-replacement disturbance, such as a major insect outbreak or major fire event, which leads to the stand initiation phase of forest development.

Community Phase 2.5: Subalpine fir-Engelmann spruce (western larch, lodgepole pine)/Rocky mountain maple/thinleaf huckleberry-white spirea-thimbleberry/queencup beadlily-beargrass

Structure: Single story with few small openings

Community Phase 2.5 is a maturing forest which is starting to differentiate vertically. Canopy cover averages 60 percent. 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. Species occurring most frequently at this community phase include the tall shrub Utah honeysuckle, medium statured shrubs Rocky mountain maple, thimbleberry, Oregon boxleaf, white spirea, thinleaf huckleberry and the lowest layer of queencup beadlily, twinflower, western meadowrue, threeleaf foamflower, darkwoods violet and beargrass. Species that occur infrequently, though in high canopy cover including Sitka alder and heartleaf arnica.
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-replacement fire disturbance, leading to the stand initiation phase of forest development.

State 3.0
Another disease affecting the 43A Lower Subalpine Coniferous Cool Moderately Dry 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 to identify the type of Armillaria root disease present and manage for pines and larch. Pre-commercial thinning may improve the 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 root 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

State 1
Historic Reference State

State 1.0 Western white pine (*Pinus monticola*)/subalpine fir (*Abies lasiocarpa*)-Engelmann spruce (*Picea engelmannii*)/thinleaf huckleberry (*Vaccinium membranaceum*)/common beargrass (*Xerophyllum tenax*)-queencup beadlily (*Clintonia uniflora*). Historically, western white pine would have been within Flathead County, Montana, 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, 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. Western white pine is susceptible to Armillaria root disease only when young, and 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, meaning it has high ecological flexibility. Western white pine 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. Moisture and soil temperature determine seed germination onset. Fire greatly influences the composition, structure, and function of vegetation across the landscape. Historically, this ecological site had mixed severity fire in between severe stand-replacement fires. Western larch and western white pine are long-lived, fire-adapted, shade-intolerant tree species that historically thrived. Also present in significant amounts, particularly in young stands, but declined through time due to the effects of insects and pathogens, were 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 in areas 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. A study of pathogens and insects effects 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 beetle were the causes 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, and 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 was 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 white pine-western larch Structure: Multistory with small gap dynamics Rare phase due to disturbance rotations

Community 1.2
Seedlings

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

Community 1.3
Pole Sized Phase

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
Vertical Differentiation in Stand

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

Community 1.5
White pine mature stand

White pine-(western larch-Douglas fir-subalpine fir-PIEN). 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 fire disturbance such as a high-intensity fire, large-scale wind event, or major insect infestation.

Pathway 1.2A
Community 1.2 to 1.3

Growth over time with no further significant disturbance.

Pathway 1.3A
Community 1.3 to 1.4

No further major disturbance. Continued growth over time, as well as ongoing mortality, leads to continued vertical diversification.

Pathway 1.3B
Community 1.3 to 1.5

A larger disturbance, such as an insect infestation, wind storm, or rot pocket that would create this forest structure.

Pathway 1.4A
Community 1.4 to 1.1

Growth over time with no further significant disturbance, leading to the reference phase.

Pathway 1.5A
Community 1.5 to 1.1

Growth over time with no further significant disturbance, leading to the reference phase.

State 2
Current Potential State

State 2.0 Subalpine fir-Engelmann spruce/Sitka alder/Thinleaf huckleberry/beargrass-queencup beadlily 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. 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 these 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.

Community 2.1
Reference Community

Plant Community 2.1-Reference Community Subalpine fir-Engelmann spruce/Sitka alder/Thinleaf huckleberry/beargrass-queencup bead lily. Structure: Multistory with Small gap dynamics. Tree age: 150 years+

Forest overstory. The forest overstory composition is dominated by subalpine fir and Engelmann spruce.

Forest understory. The forest understory composition is diverse, with tall shrubs Sitka alder, medium statured shrubs thinleaf huckleberry and common snowberry and numerous forb species including beargrass, bride's bonnet and heartleaf arnica.

Dominant plant species

- subalpine fir (*Abies lasiocarpa*), tree
- Engelmann spruce (*Picea engelmannii*), tree
- Sitka alder (*Alnus viridis ssp. sinuata*), shrub
- thinleaf huckleberry (*Vaccinium membranaceum*), shrub
- common beargrass (*Xerophyllum tenax*), other herbaceous
- bride's bonnet (*Clintonia uniflora*), other herbaceous

Table 6. Soil surface cover

Tree basal cover	0-10%
Shrub/vine/liana basal cover	5-10%
Grass/grasslike basal cover	0-2%
Forb basal cover	0-5%
Non-vascular plants	0-8%
Biological crusts	0%

Litter	80-90%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-5%

Table 7. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0-5%	0-5%	0-5%	0-10%
>0.15 <= 0.3	0-5%	0-5%	0-5%	0-10%
>0.3 <= 0.6	0-5%	10-30%	–	5-15%
>0.6 <= 1.4	0-5%	5-30%	–	–
>1.4 <= 4	0-5%	0-10%	–	–
>4 <= 12	0-5%	–	–	–
>12 <= 24	5-10%	–	–	–
>24 <= 37	20-60%	–	–	–
>37	5-10%	–	–	–

Community 2.2
Mature Stand with Open Patches

Plant Community 2.2 Subalpine fir-Engelmann spruce/Sitka alder/Thinleaf huckleberry/beargrass-queencup bead lily. Structure: Mature stand with patches. Tree age: 0-40 and 150+ years

Community 2.3
Patchy Clumps, Single Story

Plant Community 2.3 Subalpine fir-Engelmann spruce-*Pinus contorta*-Western larch/thimbleberry/ arnica-showy aster- mountain brome. Structure: patchy clumps, single story. Time spent in this phase: 20-40 years

Forest overstory. This is the post disturbance phase in which tree seedlings and establishing and growing up to the pole size stage.

Forest understory. This is post disturbance phase in which shrub and herbaceous species are resprouting or are establishing from wind-blown seeds.

Dominant plant species

- subalpine fir (*Abies lasiocarpa*), tree
- lodgepole pine (*Pinus contorta*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- western larch (*Larix occidentalis*), tree
- Engelmann spruce (*Picea engelmannii*), tree
- thimbleberry (*Rubus parviflorus*), shrub
- mountain brome (*Bromus marginatus*), grass
- arnica (*Arnica*), other herbaceous
- western showy aster (*Eurybia conspicua*), other herbaceous

Table 8. Soil surface cover

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

Table 9. Canopy structure (% cover)

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

Community 2.4
Dense Single Story

Plant Community 2.4 Lodgepole pine(Douglas fir)/thinleaf huckleberry-white spirea/pinegrass-beargrass. Structure: dense single story Time spent in this phase:25-60 years

Forest overstory. This forest overstory is dominated by lodgepole pine and is densely spaced, pole-sized trees. There can be western larch and Douglas fir present.

Forest understory. The understory is diverse and sometimes has high cover of larger forbs like beargrass, pinegrass and numerous moderate statured shrubs such as common snowberry, white spirea and thinleaf huckleberry.

Dominant plant species

- lodgepole pine (*Pinus contorta*), tree
- western larch (*Larix occidentalis*), tree
- Douglas-fir (*Pseudotsuga menziesii*), tree
- thinleaf huckleberry (*Vaccinium membranaceum*), shrub
- white spirea (*Spiraea betulifolia*), shrub
- pinegrass (*Calamagrostis rubescens*), grass
- common beargrass (*Xerophyllum tenax*), other herbaceous

Table 10. Soil surface cover

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

Table 11. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	0-5%	0-10%	0-10%
>0.15 <= 0.3	–	5-10%	0-10%	10-15%
>0.3 <= 0.6	0-2%	10-30%	–	20-40%
>0.6 <= 1.4	0-2%	10-30%	–	–
>1.4 <= 4	0-5%	0-5%	–	–
>4 <= 12	0-5%	–	–	–
>12 <= 24	40-50%	–	–	–
>24 <= 37	5-10%	–	–	–
>37	–	–	–	–

Community 2.5
Vertical differentiation in Mature Stand

Plant Community 2.5 Subalpine fir-Englemann spruce(western larch, lodgepole pine)/Rocky mountain maple/thinleaf huckleberry-white spirea-thimbleberry/queencup beadlily-beargrass. Structure: Some vertical differentiate in stand. Time spent in this phase: 20-50 years

Forest overstory. This forest has an overstory with subalpine fir and Engelmann spruce dominating the composition with less western larch and lodgepole pine. There is vertical differentiation occurring through pockets of dead trees due to wind-throw that allow small patches of regeneration to occur and create a multi-story stand.

Forest understory. The understory is diverse with pockets of herbaceous regeneration in areas of wind throw and more mature understory plants throughout the area with tall shrubs including Saskatoon serviceberry, Utah honeysuckle and Sitka alder, moderate sized shrubs including white spirea, thinkleaf huckleberry and thimbleberry and lush diverse forb species.

Dominant plant species

- subalpine fir (*Abies lasiocarpa*), tree
- Engelmann spruce (*Picea engelmannii*), tree
- Rocky Mountain maple (*Acer glabrum*), shrub
- thinleaf huckleberry (*Vaccinium membranaceum*), shrub
- white spirea (*Spiraea betulifolia*), shrub
- thimbleberry (*Rubus parviflorus*), shrub
- bride's bonnet (*Clintonia uniflora*), other herbaceous

Table 12. Soil surface cover

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

Bare ground	0-10%

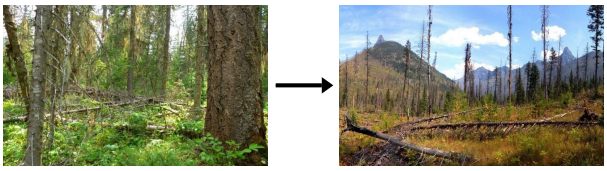
Table 13. Canopy structure (% cover)

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

Pathway 2.1A
Community 2.1 to 2.2

This pathway represents a larger disturbance, such as an insect infestation, wind storm, or rot pocket that 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



Reference Community **Patchy Clumps, Single Story**

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

Pathway 2.3A
Community 2.3 to 2.4

Patchy Clumps, Single Story Dense Single Story

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

Pathway 2.4B
Community 2.4 to 2.3

Dense Single Story Patchy Clumps, Single Story

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

Pathway 2.4A
Community 2.4 to 2.5

This pathway represents no further major disturbance. Continued growth over time

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 no further major disturbance. Continued growth over time,

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 the 43A SUBALPINE COOL MOIST CONFEROUS 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 to identify the type of Armillaria root disease present and manage for pines and larch. Pre-commercial thinning may improve growth and survival of pines and larch. Avoid harvests that leave susceptible species (usually Douglas-fir or true firs) as crop trees (Hagle, 2010). A link has been determined between parent material and susceptibility to root disease, and metasedimentary parent material is thought to increase the risk of root disease. Glacier NP is dominated by metasedimentary parent material, and therefore 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 3.1
Armillaria Root Rot

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

Transition T1A
State 1 to 2

Epidemics of white pine blister rust, western spruce budworm, and dramatic fire suppression.

Restoration pathway R2A
State 2 to 1

Infilling of shrubland with conifer seedlings, usually root rot resistant species.

Transition T2B
State 2 to 3

High density fir becomes infected.

Restoration pathway R3A
State 3 to 2

Active management and seedling of true pine and larch species.

Additional community tables

Table 14. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Tall stature, cool season bunchgrasses**			–	
	blue wildrye	ELGL	*Elymus glaucus*	–	0–5
2	**Mid stature, cool season bunchgrasses**			–	
	mountain brome	BRMA4	*Bromus marginatus*	–	0–10
3	**Carex/Juncus**			–	
	Geyer's sedge	CAGE2	*Carex geyeri*	–	0–5
6	**Rhizomatous grasses**			–	
	pinegrass	CARU	*Calamagrostis rubescens*	–	0–5
Forb					
4	**Perennial and annual forbs**			–	
	heartleaf arnica	ARCO9	*Arnica cordifolia*	–	0–10
	bride's bonnet	CLUN2	*Clintonia uniflora*	–	0–10
	western meadow-rue	THOC	*Thalictrum occidentale*	–	0–5

	pioneer violet	VIGL	*Viola glabella*	–	0–5
	northern bedstraw	GABO2	*Galium boreale*	–	0–5
	fireweed	CHAN9	*Chamerion angustifolium*	–	0–5
	Virginia strawberry	FRVI	*Fragaria virginiana*	–	0–5
	darkwoods violet	VIOR	*Viola orbiculata*	–	0–5
	western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	0–5
	American trailplant	ADBI	*Adenocaulon bicolor*	–	0–5
	yellow columbine	AQFL	*Aquilegia flavescens*	–	0–5
	heartleaf twayblade	LICO6	*Listera cordata*	–	0–5
	sidebells wintergreen	ORSE	*Orthilia secunda*	–	0–5
	meadow zizia	ZIAP	*Zizia aptera*	–	0–5
	starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	0–5
	western sweetroot	OSOC	*Osmorhiza occidentalis*	–	0–5
	claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	0–5
	green false hellebore	VEVI	*Veratrum viride*	–	0–5
	western showy aster	EUCO36	*Eurybia conspicua*	–	0–5
	Richardson's geranium	GERI	*Geranium richardsonii*	–	0–5
Shrub/Vine					
5	**Perennial shrubs and subshrubs**			–	
	thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	0–15
	white spirea	SPBE2	*Spiraea betulifolia*	–	0–10
	grouse whortleberry	VASC	*Vaccinium scoparium*	–	0–10
	Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	0–5
	thimbleberry	RUPA	*Rubus parviflorus*	–	0–5
	Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	0–5
	Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	0–5
	common snowberry	SYAL	*Symphoricarpos albus*	–	0–5
	Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	0–5
	rose	ROSA5	*Rosa*	–	0–5
	red baneberry	ACRU2	*Actaea rubra*	–	0–5
	Rocky Mountain maple	ACGL	*Acer glabrum*	–	0–5
	pipsissewa	CHUM	*Chimaphila umbellata*	–	0–5
	western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	0–5
	Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	0–5

Table 15. Community 2.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
subalpine fir	ABLA	*Abies lasiocarpa*	Native	15.2–30.5	15–40	38.1–114.3	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	15.2–30.5	10–40	38.1–114.3	–

Table 16. 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*	–	–	0.5–37.5
pinegrass	CARU	*Calamagrostis rubescens*	–	–	0.5–3
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	3
woodrush	LUZUL	*Luzula*	–	–	3
sedge	CAREX	*Carex*	–	–	0.5
Forb/Herb					
twinflower	LIBO3	*Linnaea borealis*	–	–	0.5–15
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0.5–15
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–15
American trailplant	ADBI	*Adenocaulon bicolor*	–	–	3–15
arnica	ARNIC	*Arnica*	–	–	0.5–15
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	0.5–15
aster	ASTER	*Aster*	–	–	0.5–15
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–15
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	3–15
common beargrass	XETE	*Xerophyllum tenax*	–	–	0.5–15
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–3
broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	0.5–3
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3
western showy aster	EUCO36	*Eurybia conspicua*	–	–	3
roughfruit fairybells	PRTR4	*Prosartes trachycarpa*	–	–	0.5–3
northern bedstraw	GABO2	*Galium boreale*	–	–	3
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0.5–3
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5–3
Maryland sanicle	SAMA2	*Sanicula marilandica*	–	–	3
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	0.5–3
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	3
starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	–	3
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5–3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5–3
liverleaf wintergreen	PYAS	*Pyrola asarifolia*	–	–	0.5–3
greenflowered wintergreen	PYCH	*Pyrola chlorantha*	–	–	0.5
mule-ears	WYAM	*Wyethia amplexicaulis*	–	–	0.5
bracted lousewort	PEBR	*Pedicularis bracteosa*	–	–	0.5
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	0.5
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	0.5
woodland pinedrops	PTAN2	*Pterospora andromedea*	–	–	0.5
Scouler's woollyweed	HISC2	*Hieracium scouleri*	–	–	0.5
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5
northwestern twayblade	LICA10	*Listera caurina*	–	–	0.5
heartleaf twayblade	LICO6	*Listera cordata*	–	–	0.5

[illegible]	[illegible]	[illegible]			
cream pea	LAOC2	*Lathyrus ochroleucus*	–	–	0.5
western blue virginsbower	CLOC2	*Clematis occidentalis*	–	–	0.5
bluebell bellflower	CARO2	*Campanula rotundifolia*	–	–	0.5
violet	VIOLA	*Viola*	–	–	0.5
western featherbells	STOC	*Stenanthium occidentale*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
Pacific trillium	TROV2	*Trillium ovatum*	–	–	0.5
Fern/fern ally					
Pacific oakfern	GYDI2	*Gymnocarpium disjunctum*	–	–	15
horsetail	EQUIS	*Equisetum*	–	–	3
western brackenfern	PTAQ	*Pteridium aquilinum*	–	–	0.5
Shrub/Subshrub					
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0.5–37.5
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	0.5–37.5
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–37.5
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	0.5–15
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5–15
bunchberry dogwood	COCA13	*Cornus canadensis*	–	–	3–15
redosier dogwood	COSES	*Cornus sericea ssp. sericea*	–	–	3–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–15
common snowberry	SYAL	*Symphoricarpos albus*	–	–	0.5–15
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–15
devilsclub	OPHO	*Oplopanax horridus*	–	–	3–15
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	0.5–15
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	3–15
alpine leafybract aster	SYFO2	*Symphyotrichum foliaceum*	–	–	3
dwarf red blackberry	RUPU	*Rubus pubescens*	–	–	0.5–3
Woods' rose	ROWO	*Rosa woodsii*	–	–	3
prickly currant	RILA	*Ribes lacustre*	–	–	0.5–3
russet buffaloberry	SHCA	*Shepherdia canadensis*	–	–	3
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–3
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	0.5–3
red baneberry	ACRU2	*Actaea rubra*	–	–	0.5–3
creeping barberry	MARE11	*Mahonia repens*	–	–	0.5–3
twinberry honeysuckle	LOIN5	*Lonicera involucrata*	–	–	0.5
sticky currant	RIVI3	*Ribes viscosissimum*	–	–	0.5
red elderberry	SARA2	*Sambucus racemosa*	–	–	0.5
pink mountainheath	PHEM	*Phyllodoce empetriformis*	–	–	0.5
alderleaf buckthorn	RHAL	*Rhamnus alnifolia*	–	–	0.5
Tree					
Pacific yew	TABR2	*Taxus brevifolia*	–	–	3–62.5
western larch	LAOC	*Larix occidentalis*	–	–	3–15
Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	0.5–15

paper birch	BEPA	*Betula papyrifera*	–	–	3
Nonvascular					
Moss	2MOSS	*Moss*	–	–	0.5–62.5

Table 17. Community 2.3 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	0–1.5	0–10	2.5–25.4	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	0–1.5	0–10	2.5–25.4	–
lodgepole pine	PICO	*Pinus contorta*	Native	0–1.5	0–10	2.5–25.4	–
western larch	LAOC	*Larix occidentalis*	Native	0–1.5	0–10	2.5–25.4	–

Table 18. Community 2.3 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*	–	–	3–15
needlegrass	ACHNA	*Achnatherum*	–	–	15
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	3
blue wildrye	ELGL	*Elymus glaucus*	–	–	3
Forb/Herb					
western showy aster	EUCO36	*Eurybia conspicua*	–	–	0.5–37.5
American red raspberry	RUID	*Rubus idaeus*	–	–	0.5–37.5
thimbleberry	RUPA	*Rubus parviflorus*	–	–	3–37.5
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	0.5–15
common beargrass	XETE	*Xerophyllum tenax*	–	–	0.5–15
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–15
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0.5–15
streambank wild hollyhock	ILRI	*Iliamna rivularis*	–	–	0.5–15
fireweed	CHAN9	*Chamerion angustifolium*	–	–	3–15
western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	0.5–15
arnica	ARNIC	*Arnica*	–	–	15
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	15
broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	15
common yarrow	ACMI2	*Achillea millefolium*	–	–	0.5–3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	3
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–3
northwestern twayblade	LICA10	*Listera caurina*	–	–	3
lupine	LUPIN	*Lupinus*	–	–	3
goldenrod	SOLID	*Solidago*	–	–	3
Scouler's woollyweed	HISC2	*Hieracium scouleri*	–	–	0.5–3
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5–3
woodland strawberry	FRVE	*Fragaria vesca*	–	–	3

Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	3
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	0.5–3
Maryland sanicle	SAMA2	*Sanicula marilandica*	–	–	3
wormleaf stonecrop	SEST2	*Sedum stenopetalum*	–	–	0.5
pussytoes	ANTEN	*Antennaria*	–	–	0.5
prickly currant	RILA	*Ribes lacustre*	–	–	0.5
dwarf red blackberry	RUPU	*Rubus pubescens*	–	–	0.5
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	0.5
common dandelion	TAOF	*Taraxacum officinale*	–	–	0.5
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5
northern bedstraw	GABO2	*Galium boreale*	–	–	0.5
twinflower	LIBO3	*Linnaea borealis*	–	–	0.5
Canada thistle	CIAR4	*Cirsium arvense*	–	–	0.5
bluebell bellflower	CARO2	*Campanula rotundifolia*	–	–	0.5
spreading dogbane	APAN2	*Apocynum androsaemifolium*	–	–	0.5
Fern/fern ally					
western brackenfern	PTAQ	*Pteridium aquilinum*	–	–	3
Shrub/Subshrub					
snowbrush ceanothus	CEVE	*Ceanothus velutinus*	–	–	3–37.5
willow	SALIX	*Salix*	–	–	0.5–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–15
rose meadowsweet	SPSP2	*Spiraea splendens*	–	–	15
common snowberry	SYAL	*Symphoricarpos albus*	–	–	0.5–3
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–3
red elderberry	SARA2	*Sambucus racemosa*	–	–	3
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–3
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	3
creeping barberry	MARE11	*Mahonia repens*	–	–	0.5–3
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–3
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	0.5
Michaux's wormwood	ARMI4	*Artemisia michauxiana*	–	–	0.5
bunchberry dogwood	COCA13	*Cornus canadensis*	–	–	0.5
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	0.5
Drummond's willow	SADR	*Salix drummondiana*	–	–	0.5
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	0.5
Tree					
Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	0.5–3
western larch	LAOC	*Larix occidentalis*	–	–	0.5–3
quaking aspen	POTR5	*Populus tremuloides*	–	–	0.5
Nonvascular					

Moss	2MOSS	*Moss*	–	–	3

Table 19. Community 2.4 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
lodgepole pine	PICO	*Pinus contorta*	Native	9.1–24.4	15–65	25.4–50.8	–
subalpine fir	ABLA	*Abies lasiocarpa*	Native	9.1–24.4	3–35	25.4–50.8	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	9.1–24.4	3–35	25.4–50.8	–
Douglas-fir	PSME	*Pseudotsuga menziesii*	Native	9.1–24.4	3–35	25.4–50.8	–
western larch	LAOC	*Larix occidentalis*	Native	9.1–24.4	3–15	25.4–50.8	–

Table 20. Community 2.4 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
pinegrass	CARU	*Calamagrostis rubescens*	–	–	3–37.5
mountain brome	BRMA4	*Bromus marginatus*	–	–	3
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0.5
Forb/Herb					
arnica	ARNIC	*Arnica*	–	–	62.5
common beargrass	XETE	*Xerophyllum tenax*	–	–	0.5–62.5
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	0.5–37.5
spreading dogbane	APAN2	*Apocynum androsaemifolium*	–	–	15
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–15
roughfruit fairybells	PRTR4	*Prosartes trachycarpa*	–	–	15
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	0.5–15
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–15
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	0.5–15
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	0.5–3
strawberry	FRAGA	*Fragaria*	–	–	0.5–3
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5–3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5–3
liverleaf wintergreen	PYAS	*Pyrola asarifolia*	–	–	3
greenflowered wintergreen	PYCH	*Pyrola chlorantha*	–	–	0.5–3
Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	0.5–3
northern bedstraw	GABO2	*Galium boreale*	–	–	0.5–3
fragrant bedstraw	GATR3	*Galium triflorum*	–	–	3
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5–3
western showy aster	EUCO36	*Eurybia conspicua*	–	–	0.5–3
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5–3
twinflower	LIBO3	*Linnaea borealis*	–	–	3

broadleaf arnica	ARLA8	*Arnica latifolia*	–	–	3
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–3
western blue virginsbower	CLOC2	*Clematis occidentalis*	–	–	0.5
common yarrow	ACMI2	*Achillea millefolium*	–	–	0.5
American trailplant	ADBI	*Adenocaulon bicolor*	–	–	0.5
northwestern twayblade	LICA10	*Listera caurina*	–	–	0.5
lupine	LUPIN	*Lupinus*	–	–	0.5
yellow avalanche-lily	ERGR9	*Erythronium grandiflorum*	–	–	0.5
Scouler's woollyweed	HISC2	*Hieracium scouleri*	–	–	0.5
western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	0.5
cream pea	LAOC2	*Lathyrus ochroleucus*	–	–	0.5
starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	–	0.5
pinedrops	PTERO3	*Pterospora*	–	–	0.5
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5
violet	VIOLA	*Viola*	–	–	0.5
Fern/fern ally					
western brackenfern	PTAQ	*Pteridium aquilinum*	–	–	15
Shrub/Subshrub					
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–37.5
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–15
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0.5–15
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	0.5–15
bunchberry dogwood	COCA13	*Cornus canadensis*	–	–	3–15
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	0.5–15
kinnikinnick	ARUV	*Arctostaphylos uva-ursi*	–	–	3
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	3
creeping barberry	MARE11	*Mahonia repens*	–	–	0.5–3
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–3
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	0.5–3
Woods' rose	ROWO	*Rosa woodsii*	–	–	3
Scouler's willow	SASC	*Salix scouleriana*	–	–	3
red elderberry	SARA2	*Sambucus racemosa*	–	–	3
russet buffaloberry	SHCA	*Shepherdia canadensis*	–	–	3
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	0.5–3
common snowberry	SYAL	*Symphoricarpos albus*	–	–	0.5–3
rose	ROSA5	*Rosa*	–	–	0.5
prickly currant	RILA	*Ribes lacustre*	–	–	0.5
sticky currant	RIVI3	*Ribes viscosissimum*	–	–	0.5
redosier dogwood	COSES	*Cornus sericea ssp. sericea*	–	–	0.5
red baneberry	ACRU2	*Actaea rubra*	–	–	0.5
Tree					

Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	0.5–15
paper birch	BEPA	*Betula papyrifera*	–	–	15
western larch	LAOC	*Larix occidentalis*	–	–	3–15
quaking aspen	POTR5	*Populus tremuloides*	–	–	0.5–15
Nonvascular					
Moss	2MOSS	*Moss*	–	–	37.5

Table 21. Community 2.5 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
subalpine fir	ABLA	*Abies lasiocarpa*	Native	9.1–30.5	5–40	38.1–88.9	–
Engelmann spruce	PIEN	*Picea engelmannii*	Native	9.1–30.5	5–40	38.1–88.9	–
western larch	LAOC	*Larix occidentalis*	Native	9.1–30.5	5–40	38.1–88.9	–
Douglas-fir	PSME	*Pseudotsuga menziesii*	Native	9.1–30.5	5–40	38.1–88.9	–
lodgepole pine	PICO	*Pinus contorta*	Native	9.1–30.5	5–40	38.1–88.9	–

Table 22. Community 2.5 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
pinegrass	CARU	*Calamagrostis rubescens*	–	–	0.5–15
Geyer's sedge	CAGE2	*Carex geyeri*	–	–	0.5–3
mountain brome	BRMA4	*Bromus marginatus*	–	–	0.5–3
Forb/Herb					
heartleaf arnica	ARCO9	*Arnica cordifolia*	–	–	0.5–62.5
western meadow-rue	THOC	*Thalictrum occidentale*	–	–	0.5–37.5
common beargrass	XETE	*Xerophyllum tenax*	–	–	0.5–37.5
violet	VIOLA	*Viola*	–	–	15
threeleaf foamflower	TITR	*Tiarella trifoliata*	–	–	0.5–15
claspleaf twistedstalk	STAM2	*Streptopus amplexifolius*	–	–	0.5–15
American trailplant	ADBI	*Adenocaulon bicolor*	–	–	0.5–15
western pearly everlasting	ANMA	*Anaphalis margaritacea*	–	–	0.5–15
bride's bonnet	CLUN2	*Clintonia uniflora*	–	–	0.5–15
fireweed	CHAN9	*Chamerion angustifolium*	–	–	0.5–15
roughfruit fairybells	PRTR4	*Prosartes trachycarpa*	–	–	15
twinflower	LIBO3	*Linnaea borealis*	–	–	0.5–15
Scouler's woollyweed	HISC2	*Hieracium scouleri*	–	–	0.5–3
narrowleaf hawkweed	HIUM	*Hieracium umbellatum*	–	–	0.5–3
cream pea	LAOC2	*Lathyrus ochroleucus*	–	–	0.5–3
woodland strawberry	FRVE	*Fragaria vesca*	–	–	3
Virginia strawberry	FRVI	*Fragaria virginiana*	–	–	0.5–3

fragrant bedstraw	GATR3	*Galium triflorum*	–	–	0.5–3
goldenrod	SOLID	*Solidago*	–	–	3
feathery false lily of the valley	MARA7	*Maianthemum racemosum*	–	–	0.5–3
starry false lily of the valley	MAST4	*Maianthemum stellatum*	–	–	3
sidebells wintergreen	ORSE	*Orthilia secunda*	–	–	0.5–3
sweetcicely	OSBE	*Osmorhiza berteroi*	–	–	0.5–3
Indian paintbrush	CASTI2	*Castilleja*	–	–	3
greenflowered wintergreen	PYCH	*Pyrola chlorantha*	–	–	0.5–3
pipsissewa	CHUM	*Chimaphila umbellata*	–	–	0.5–3
aster	ASTER	*Aster*	–	–	0.5–3
arnica	ARNIC	*Arnica*	–	–	3
darkwoods violet	VIOR	*Viola orbiculata*	–	–	0.5–3
Pacific trillium	TROV2	*Trillium ovatum*	–	–	0.5
strawberry	FRAGA	*Fragaria*	–	–	0.5
arrowleaf ragwort	SETR	*Senecio triangularis*	–	–	0.5
green false hellebore	VEVI	*Veratrum viride*	–	–	0.5
spreading dogbane	APAN2	*Apocynum androsaemifolium*	–	–	0.5
wild sarsaparilla	ARNU2	*Aralia nudicaulis*	–	–	0.5
Canada thistle	CIAR4	*Cirsium arvense*	–	–	0.5
western showy aster	EUCO36	*Eurybia conspicua*	–	–	0.5
pinedrops	PTERO3	*Pterospora*	–	–	0.5
woodland pinedrops	PTAN2	*Pterospora andromedea*	–	–	0.5
western sweetroot	OSOC	*Osmorhiza occidentalis*	–	–	0.5
western rattlesnake plantain	GOOB2	*Goodyera oblongifolia*	–	–	0.5
common cowparsnip	HEMA80	*Heracleum maximum*	–	–	0.5
Fern/fern ally					
northern hollyfern	POLO4	*Polystichum lonchitis*	–	–	0.5
Shrub/Subshrub					
thinleaf huckleberry	VAME	*Vaccinium membranaceum*	–	–	0.5–62.5
Sitka alder	ALVIS	*Alnus viridis ssp. sinuata*	–	–	3–37.5
American red raspberry	RUID	*Rubus idaeus*	–	–	37.5
thimbleberry	RUPA	*Rubus parviflorus*	–	–	0.5–37.5
Oregon boxleaf	PAMY	*Paxistima myrsinites*	–	–	0.5–15
Utah honeysuckle	LOUT2	*Lonicera utahensis*	–	–	0.5–15
Saskatoon serviceberry	AMAL2	*Amelanchier alnifolia*	–	–	0.5–15
willow	SALIX	*Salix*	–	–	15
russet buffaloberry	SHCA	*Shepherdia canadensis*	–	–	3–15
Greene's mountain ash	SOSC2	*Sorbus scopulina*	–	–	0.5–15
white spirea	SPBE2	*Spiraea betulifolia*	–	–	0.5–15
common snowberry	SYAL	*Symphoricarpos albus*	–	–	0.5–15
red elderberry	SARA2	*Sambucus racemosa*	–	–	0.5–3
grouse whortleberry	VASC	*Vaccinium scoparium*	–	–	0.5–3
snowbrush ceanothus	CEVE	*Ceanothus velutinus*	–	–	3
bunchberry dogwood	COCA13	*Cornus canadensis*	–	–	0.5–3

creeping barberry	MARE11	*Mahonia repens*	–	–	0.5–3
rusty menziesia	MEFE	*Menziesia ferruginea*	–	–	0.5–3
twinberry honeysuckle	LOIN5	*Lonicera involucrata*	–	–	0.5–3
prickly currant	RILA	*Ribes lacustre*	–	–	0.5–3
sticky currant	RIVI3	*Ribes viscosissimum*	–	–	3
Woods' rose	ROWO	*Rosa woodsii*	–	–	0.5–3
dwarf red blackberry	RUPU	*Rubus pubescens*	–	–	0.5
Scouler's willow	SASC	*Salix scouleriana*	–	–	0.5
Tree					
Rocky Mountain maple	ACGL	*Acer glabrum*	–	–	3–37.5
Pacific yew	TABR2	*Taxus brevifolia*	–	–	3–15
paper birch	BEPA	*Betula papyrifera*	–	–	0.5–3
quaking aspen	POTR5	*Populus tremuloides*	–	–	0.5–3
black cottonwood	POBAT	*Populus balsamifera ssp. trichocarpa*	–	–	0.5
Nonvascular					
Moss	2MOSS	*Moss*	–	–	0.5–37.5

Other references

References

Arno, S. Forest Regions of Montana. USDA Forest Service Research Paper INT-218. USFS. USDA.

Arno, S. and R. Hammerly. Northwest Trees, by Stephen F. Arno and Ramona P. Hammerly. Anniversary Edition, the Mountaineers Books, 2007.

Arno S., D. Parsons and R. Keane. Mixed-Severity Fire Regimes in the Northern Rocky Mountains: Consequences of Fire Exclusion and Options for the Future. USDA Forest Service Proceedings RMRS-P-15-VOL-5.2000.

Bollenbacher, B. and P. Kolb, J. Morrison. 2013. Review Draft: Vulnerability, exposure, and sensitivity in restoring and maintaining the adaptive capacity of forest landscapes in the northern region of the Northern Rocky Mountains.

Barrett, S., S. Arno and C. Key. Fire regimes of western larch-lodgepole pine forests in Glacier National Park, Montana. 1991.

Byler, James and Hagle, Susan. 2000. Succession functions of pathogens and insects. FHP Report No. 00-09.
Fins, Lauren, et al. "Return of the giants: restoring western white pine to the Inland Northwest." Journal of forestry 100.4 (2002): 20-26.

Fischer W., A. Bradley. Fire Ecology of Western Montana Forest Habitat Types. US Department of Agriculture. Forest Service. Intermountain Research Station. GTR-INT-223.

Garrison-Johnston, R. Lewis, L. Johnson. 2007. Northern Idaho and Western Montana Nutrition Guidelines by Rock Type. Intermountain Forest Tree Nutrition Cooperative. Forest Resources Department, University of Idaho.

Green, P., J. Joy, D. Sirucek, W. Hann, A. Zack and B. Naumann. Old-Growth forest types of the Northern Region. 1992. Northern Region, USDA Forest Service. R-1 SES 4/92.

Hagle S., USFS, Forest Health Protection and State Forestry Organizations. Management Guide for Armillaria Root Disease. February 2008. WEB July 2010.

Hagle, Susan K. "Succession functions of forest pathogens and insects." (2000).

Haig, Irvine, Davis, Kenneth and Weidman, Robert. Natural regeneration in the western white pine type. Technical

Bulletin no. 767. May 1941. Northern Rocky mountain Forest and Range Experiment Station. USFS.

Harvey A., James Byler, Gerald McDonald, Leon Neuenschwander, Jonalea Tonn. Death of an Ecosystem: Perspectives on Western White Pine Ecosystems of North America at the End of the Twentieth Century. USDA Forest Service RMRS-GTR-208. 2008.

Hoff, Raymond J., Geral I. McDonald, and Richard T. Bingham. Mass selection for blister rust resistance: a method for natural regeneration of western white pine. US Dept. of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, 1976.

Kimsey M., T. Shaw, M. Johnston, P. McDaniel. Intermountain Forest Tree Nutrition Cooperative. Ecological and physiological overview of volcanic soils and their influence on tree growth and vegetation.

Kimsey M. Intermountain Forest Tree Nutrition Cooperative. Geospatial tools for estimating and maintaining soil-site productivity. Northwest Forest Soils Council Meeting, February 28, 2012.

Lauren Fins, James Byler, Dennis Ferguson, Al Harvey, Mary Frances Mahalovich, Gerald McDonald, Dan Miller, John Schwandt, and Art Zack. Return of the Giants.

Little, E.L., Jr. Digital Representation of “Atlas of United States Trees”; U.S. Geological Survey Professional Paper 1650; U.S. Geological Survey: Reston, VA, USA, 1999. [Google Scholar]
Vulnerability, Exposure, and Sensitivity in Restoring and maintaining the adaptive capacity of forest landscapes in the Northern Region of the Northern Rocky Mountains. Review Draft.

Loehman, Rachel A., Jason A. Clark, and Robert E. Keane. "Modeling effects of climate change and fire management on western white pine (*Pinus monticola*) in the Northern Rocky Mountains, USA." Forests 2.4 (2011): 832-860.

Losensky, B. J. 1992. Canyon Creek Fire Report, Scapegoat Wilderness. Unpublished data on file at USDA Forest Service, Lolo National Forest, Missoula, Montana, USA.

Mahalovich, Mary F. "The role of genetics in improving forest health." (1995).

McDonald, A. Harvey and J. Tonn. 2000. USDA U.S.F.S., Rocky Mountain Research Station. Fire, competition and forest pests: landscape treatment to sustain ecosystem function.

McKenzie, D. and D. Tinker. 2012. Fire-induced shifts in overstory tree species composition and associated understory plant composition in Glacier National Park, Montana. Plant Ecology 2012: 213:207-224.

NatureServe, 2007. U.S. National Vegetation Classification Standard: Terrestrial Ecological Classifications. Waterton-Glacier International Peace Park, Local and Global Association Descriptions.

N.P.S. Fire Ecology Annual Report, Calendar Year 2014.

Pfister, R., B. Kovalchik, S. Arno, R. Presby. Forest Habitat Types of Montana. USDA Forest Service General Technical Report INT-34. Intermountain Forest and Range Experiment Station, US Department of Agriculture. May 1977.

Rockwell, F.I. 1917. Western white pine bulletin.

Soil Survey Staff. 2015. Illustrated guide to soil taxonomy. U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska.

Tomback, Diana F., and Peter Achuff. "Blister rust and western forest biodiversity: ecology, values and outlook for white pines." Forest Pathology 40.3-4 (2010): 186-225.

USDA Forest Service. 1998. Flathead National Forest Plan Amendment 21, Final Environmental Impact Statement: Management Direction Related to Old Growth Forests. Flathead National Forest, Kalispell, MT.

USDA USFS Aerial Detection Survey Map, 2014.

Zack, A. Region One, Vegetation Classification, mapping, inventory and analysis report. U.S. Department of Agriculture, US Forest Service, Northern Region. Report 09-08 v1.0. 1997, revised 2005.

Approval

Kirt Walstad, 5/03/2024

Rangeland health reference sheet

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

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