

Ecological site F022BI115CA Frigid And Cryic Gravelly Slopes

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

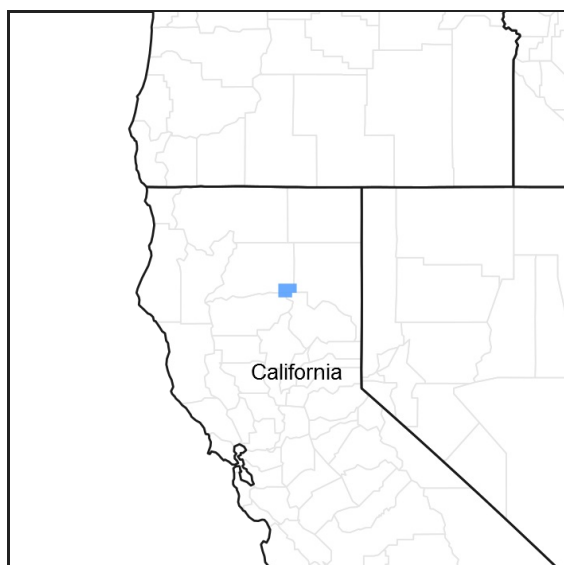


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 022B–Southern Cascade Mountains

Site concept:

Landform: (1) Outwash terrace, (2) Moraine, (3) Mountain slope

Elevation (feet): 5,720-8,700

Slope (percent): 0-80

Water Table Depth (inches): n/a

Flooding-Frequency: None

Ponding-Frequency: None

Aspect: South, East, Northeast

Mean annual precipitation (inches): 35.0-117.0

Primary precipitation: Winter months in the form of snow

Mean annual temperature: 38 to 43 degrees F (3.3 to 6.1 degrees C)

Restrictive Layer: Varies -- indurated andesite bedrock is encountered between 20 to 40 inches; densic horizon from compacted till occurs at 20 to 60 inches; silica cemented duripan ranges from 20 to 40 inches

Temperature Regime: Cryic/frigid

Moisture Regime: Xeric

Parent Materials: Volcanic deposits such as ash, tephra, debris flow, or pyroclastic flow over till or colluvium

Surface Texture: (1) Ashy Loamy coarse sand, (2) Gravelly ashy sandy loam, (3) Gravelly ashy loamy sand

Surface Fragments <=3" (% Cover): 0-75

Surface Fragments > 3" (% Cover): 1-75

Soil Depth (inches): 20-80

Vegetation: Open California red fir (*Abies magnifica*) and western white pine (*Pinus monticola*) forest with the understory almost a monopoly of pinemat manzanita (*Arctostaphylos nevadensis*).

Classification relationships

Forest Alliance = *Abies magnifica* – Red fir forest; Association = *Abies magnifica*-*Pinus monticola*/*Arctostaphylos nevadensis*. (Sawyer, John O., Keeler-Wolf, Todd, and Evens, Julie M. 2009. A Manual of California Vegetation. 2nd ed. California Native Plant Society Press. Sacramento, California.)

Associated sites

F022BI107CA	Frigid Moderately Deep Slopes This is a California red fir-white fir forest found at lower elevations.
R022BI204CA	Glaciated Mountain Slopes This is a pinemat manzanita rangeland site, which does not develop into a forest.

Similar sites

F022BI102CA	Frigid Bouldery Glacially Scoured Ridges Or Headlands This is an open California red fir forest with some western white pine and Sierra lodgepole pine, with exposed bedrock outcrops.
F022BI114CA	Frigid Very Deep Cinder Cone Or Shield Volcano Slopes This is an open California red fir-western white pine forest with high cover of volcanic rubble.

Table 1. Dominant plant species

Tree	(1) <i>Abies magnifica</i> (2) <i>Pinus monticola</i>
Shrub	(1) <i>Arctostaphylos nevadensis</i>
Herbaceous	(1) <i>Achnatherum occidentale</i>

Physiographic features

This site is found on outwash terraces, moraines, glacial-valley walls, glacial-valley floors, glaciated volcanic domes, and glaciated lava plateaus. Although the majority of this site is found between 6,200 and 7,500 feet in elevation, it is mapped higher or lower in some areas. Slopes are generally between 2 to 45 percent but associated map units have slopes from 0 to 80 percent.

Table 2. Representative physiographic features

Landforms	(1) Outwash terrace (2) Moraine (3) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	1,743–2,652 m
Slope	0–80%
Aspect	NE, E, S

Climatic features

This ecological site receives most of its annual precipitation in the winter months in the form of snow. The mean annual precipitation ranges from 35 to 117 inches (889 to 2,972 mm) and the mean annual temperature ranges

from 38 to 43 degrees F (3.3 to 6.1 degrees C). The frost free (>32 degrees F) season is 50 to 85 days. The freeze free (>28 degrees F) season is 60 to 190 days.

There are no representative climate stations for this site.

Table 3. Representative climatic features

Frost-free period (average)	85 days
Freeze-free period (average)	190 days
Precipitation total (average)	2,972 mm

Influencing water features

This ecological site is not influenced by wetland or riparian water features.

Soil features

This site is associated with 10 soil components that straddle the cryic/frigid soil temperature regimes. Most of this site is associated with volcanic deposits such as ash, tephra, debris flow, or pyroclastic flow over till, outwash or colluvium. The soils are moderately deep to very deep and well drained. The surface textures are predominately gravelly ashy loamy coarse sand, gravelly sandy loam, and gravelly loamy sand. The subsurface soils have a high percentage of cobbles or stones with coarse textures.

A few of the soil components are discussed in more detail below.

The Cenplat soils are moderately deep well drained soils that formed in tephra over residuum from volcanic rock. They are found on glacially scoured lava plateaus. They are classified as Ashy over medial-skeletal, glassy over amorphic, frigid Typic Haploxerands. They have about 8 inches of tephra over buried soil. There is a thin layer of needles and twigs over a thin A horizon, from 0 to 2 inches below the surface. The A horizon has an ashy loamy sand texture. The lower tephra deposits are designated as a C1 and C2 horizon, and have ashy sand and extremely cobbly ashy coarse sand textures respectively. There are three Bwb horizons below the tephra deposits (from 8 to 31 inches), which have extremely cobbly medial sandy loam textures. Indurated andesite bedrock is encountered between 20 to 40 inches below the surface.

The Cascadesprings soils are moderately deep, well drained soils that formed in tephra over till from volcanic rocks. They are found on ground moraines. They are classified as Ashy over medial-skeletal, glassy over amorphic, frigid Typic Vitrixerands. There is a very thin O horizon of needles and twigs over two A horizons. The A horizons, from 0.4 to 9 inches, have gravelly ashy loamy coarse sand textures. There are two Bwb horizons from 9 to 17 and 17 to 27 inches with very gravelly medial coarse sandy loam and very stony medial loamy coarse sand textures respectively. A densic horizon from compacted till occurs at 20 to 40 inches.

The Emeraldlake soils are associated with this ecological site at the lowest extent of their range, on the south slopes of Reading Peak. The Emeraldlake soils are very deep, somewhat excessively drained soils that formed in tephra mixed with colluvium from volcanic rocks. Emeraldlake soils are on cirque walls, volcanic domes, colluvial aprons and mountain slopes. They are classified as Ashy-skeletal, amorphic, nonacid Vitrandic Cryorthents. These soils have 3 A horizons from 0 to 14 inches, with extremely gravelly ashy fine sandy loam and extremely gravelly ashy loamy sand textures. There are two Bw horizons from 14 inches to 35 inches with extremely gravelly ashy loamy coarse sand textures. These horizons have 57 to 65 percent gravels with 10 percent cobbles and 0 to 10 percent stones. The two lower Bw horizons have ashy boulder textures with 26 percent gravel and 70 percent stones and boulders.

The Terracelake soils are moderately deep, well drained soils that formed in tephra over or mixed with colluvium and residuum from volcanic rock. Terracelake soils are on glaciated volcanic domes, glaciated mountain slopes, glaciated lava flows, scoured glacial valley walls and floors, and roche moutonnees. They are classified as Ashy-skeletal, amorphic Xeric Vitricryands. There is a thin O horizon. Two A horizons from 1 to 7 inches have gravelly ashy sandy loam textures. Two Bwb horizons are between 17 to 24 inches with very gravelly ashy fine sandy loam and extremely gravelly ashy fine sandy loam textures. A Bqb horizon (which designates silica accumulation) occurs

from 24 to 27 inches with an extremely stony ashy sandy loam texture. Dacite bedrock occurs between 20 to 40 inches.

The Andic Durixerpts soil component is composed of moderately deep, well drained soils that formed in ash over glacial outwash from volcanic rocks. They are found on upper elevation outwash terraces. They are classified as Ashy-skeletal, amorphic, frigid Andic Durixerpts. They have a thin layer of needles and twigs. The A horizon is from 1 to 3 inches below the surface and has a gravelly ashy loamy coarse sand texture. The two Bw horizons from 3 to 19 inches have extremely cobbly ashy coarse sandy loam and extremely gravelly ashy coarse sandy loam textures. Two Bq horizons occur from 19 to 31 inches. The upper Bq horizon has an extremely gravelly ashy loamy coarse sand texture, and the lower horizon has a cemented extremely gravelly ashy coarse sandy loam texture. The depth of the silica cemented duripan ranges from 20 to 40 inches.

The Shadowlake soils consist of deep, well drained soils that formed in tephra over or mixed with till from volcanic rocks. They are located on ground moraines and glacial- valley walls and floors. Shadowlake soils are classified as Ashy-skeletal, glassy Xeric Vitricryands. They have a thin layer of needles and twigs overlaying a thin A horizon. The A horizon is from 1 to 2 inches below the surface and has a gravelly ashy sandy loam texture. Three Bw horizons occur between 2 to 23 inches and have gravelly ashy sandy loam or very gravelly ashy sandy loam textures. A Bq horizon occurs from 23 to 41 inches and has an extremely gravelly ashy coarse sandy loam texture. A root restrictive densic horizon occurs at 41 inches, but can vary from 40 to 60 inches.

The Readingpeak soils are associated with this ecological site, the lowest extent occurring on the south side of Reading Peak. Readingpeak soils are deep and formed in tephra over colluvium and residuum weathered from andesite, dacite and rhyodacite. They are classified as Ashy-skeletal, amorphic Xeric Vitricryands. The Sueredo soil series is associated with this site as a minor component and only occurs at the highest elevations where Sueredo soils are mapped. These soils are very deep and formed in tephra over till from volcanic rocks. They are classified as Ashy-skeletal, mixed, frigid Typic Vitrixerands.

The Vitrandic Cryorthents, debris flows and the Xeric Vitricryands, pyroclastic surge soil components are associated with the 1915 eruption of Lassen Peak. The Vitrandic Cryorthents, debris flows are moderately deep to very deep and formed in pyroclastic and debris flows over glacial till from volcanic rocks or debris flows. The Xeric Vitricryands, pyroclastic surge component is deep to very deep and formed in pyroclastic surges over till from volcanic rocks. The forest in this area was destroyed during the eruption, and has been going through the process of primary and secondary succession. Ecological site F022BI106CA has more detailed information about primary succession after the 1915 eruption.

Permeability varies by soil component, but in general the upper horizons have moderately rapid to very rapid permeability, and are very slowly permeable to impermeable through duripans, densic layers, or bedrock.

This ecological site is associated with the following soil components within the Lassen Volcanic National Park Soil Survey Area (CA789):

Map Unit Component, Comp %

106 Cenplat, 70

106 Cascadesprings, 5

112 Cascadesprings, 85

112 Emeraldlake, 2

113 Emeraldlake, 25

113 Readingpeak, 20

113 Cascadesprings, 2

132 Vitrandic Cryorthents-debris flows, 90

132 Xeric Vitricryands-pyroclastic surge, 3

143 Andic Durixerpts, 95

143 Cascadesprings, 3

150 Shadowlake, 40

150 Terracelake, 30

151 Terracelake, 40

151 Shadowlake, 15

151 Sueredo, 5

- 152 Terracelake, 35
- 152 Shadowlake ,30
- 152 Sueredo, 4
- 153 Vitrandic Cryorthents-debris flows, 2
- 154 Vitrandic Cryorthents-debris flows, 2
- 155 Xeric Vitricryands-pyroclastic surge, 90
- 155 Vitrandic Cryorthents-debris flows, 5
- 155 Shadowlake, 3
- 156 Xeric Vitricryands-pyroclastic surge, 90
- 156 Shadowlake, 5
- 171 Shadowlake, 5
- 175 Terracelake, 5

Table 4. Representative soil features

Family particle size	(1) Sandy
Drainage class	Well drained
Permeability class	Very rapid
Soil depth	51–203 cm
Surface fragment cover <=3"	0–75%
Surface fragment cover >3"	1–75%
Available water capacity (0-101.6cm)	0.08–13.64 cm
Soil reaction (1:1 water) (0-101.6cm)	4.5–7.3
Subsurface fragment volume <=3" (Depth not specified)	5–70%
Subsurface fragment volume >3" (Depth not specified)	0–70%

Ecological dynamics

This ecological site is dominated by an open California red fir (*Abies magnifica*) and western white pine (*Pinus monticola*) forest with the understory almost a monopoly of pinemat manzanita (*Arctostaphylos nevadensis*).

The canopy cover in this forest site ranges from 15 to 35 percent with wide open patches of pinemat manzanita. In some areas this site could pass for a rangeland site, but these trees have the potential to develop denser canopies and forest structures. This site is most commonly found on northeastern exposures, but aspect varies from north to southwest. The western exposures tend to have more cover of green leaf manzanita (*Arctostaphylos patula*) and bush chinquapin (*Chrysolepis sempervirons*).

The soils associated with this site have several similarities. Most are moderately deep and the deep and very deep soils are skeletal, meaning they have greater than 35 percent rock fragments. Because of root limiting layers and/or high rock fragments these soils have very low to moderate available water capacity (AWC). The Terracelake and Sueredo soils are the only soils with moderate AWC. Most of these soils have ash or tephra deposits 3 to 10 inches deep which overlay or are mixed in with the pre-existing soil. The tephra deposits have very similar surface textures. Unmixed tephra deposits have an ashy loamy sand or gravelly ashy loamy coarse sand textures. When the tephra mixed with colluvium and/or residuum, extremely gravelly ashy fine sandy loams and gravelly ashy sandy loam textures develop. The tephra deposits are from various sources, depending on the location. The eruptions from Chaos Crag (about 1,100 years ago), Cinder Cone (about 300 years ago), and/or Lassen Peak deposited tephra and ash on these soils. The A horizons are generally very thin with low organic matter accumulation over an undeveloped C horizon. Buried soils below generally have sandy loam textures, with developed soil structure and mineral weathering. The tephra layer can act as an insulator from heat and reduce water loss from the lower soil horizons. It may also reduce the capillary flow from the lower soils to the surface, allowing free water to infiltrate to deeper depths.

Pinemat manzanita resprouts from adventitious roots, when branches are buried by soil. This regeneration strategy may have enabled pinemat manzanita to re-establish through the tephra deposits. It produces and collects litter slowly and will accumulate organic matter in the tephra. Pinemat manzanita is very low growing but can provide limited shade for conifer seedlings.

California red fir (*Abies magnifica*) is generally dominant in this ecological site. California red fir is a tall, long lived conifer with short branches and a narrow crown. It produces single 0.8 to 1.4 inch long needles that are distributed along the young branches. Firs produce upright cones that open and fall apart while still attached to the tree, so cones are not often seen on the forest floor unless cut by squirrels or chipmunks in fall. California red fir cones are about 9 inches long. California red fir prefers cold wet winters in areas with deep snow accumulation followed by warm summers. The young trees have thin bark and are very susceptible to fire, but as trees mature the bark thickens and fire resistance increases.

Western white pine is also a long lived conifer with a narrow crown. It has 2 to 4 inch long needles in bundles of 5. It produces a deep tap root and extensive lateral roots. Most of the lateral roots are within the upper 2 feet of soil. Young trees have thin bark and are very susceptible to fire due to damage to the cambial tissue. Mature trees develop thicker bark and have higher branches, making them less prone to mortality from fire (Griffith, 1992). Western white pine bark, when damaged by fire, can allow infestation of pathogens that can eventually kill the tree.

Conifers have evolved with their environment developing characteristics that enable them to survive specific climatic conditions. Temperature and precipitation are important environmental variables that determine which conifer species are most likely to be present in a given area. Temperature is critical in initiating conifer growth after snowmelt. Trees generally start stem growth about 2 weeks after snow melt, a delay that may be related to the warming of soils and roots. If the snow melt is unusually early, trees will not begin annual growth until specific air temperatures and/or a photoperiod (a ratio of light hours to dark hours during one 24 hour period) is met. The pines associated with this site begin leader growth at cooler temperatures than the firs. The pines have heavily insulated terminal buds, whereas the terminal buds of the fir trees are less insulated and more susceptible to frost damage (Royce and Barbour, 2001). Seedling establishment and survival are also dependent upon the frost resistance of the species. After temperatures and the photo period criteria have been met, precipitation and soil available water determine the length of the growing season. The length of the leader growth is predetermined by growth conditions of the prior year. If drought conditions set in before the leader has reached its determinate length, growth will be terminated prematurely. If precipitation comes after the snow has melted, it can prolong the growing season. Conifer growth ceases with the onset of drought conditions and the decline of water potentials (Royce and Barbour, 2001). In addition to drought conditions, the growing season is shorter at higher elevations due to late snow melt and early frost dates in fall. California red fir takes advantage of the short growing season with rapid initial growth, which gradually declines through the summer (Royce and Barbour, 2001).

This forest has evolved with fire over the centuries. It is relatively open, slow growing, and accumulates fuels slowly. Therefore fire spreads across this site less frequently than lower elevation conifer forests. The point fire return interval for the red fir-western white pine forest on Prospect Peak between the years of 1685 and 1937 ranged from 26 to 109 years, with a mean of 70 (Taylor, 2000). In the Thousand Lakes Wilderness point fire return interval ranges from 4 to 55 years with a mean of 24 for red fir-white fir forests, and 9 to 91 years with a mean of 20 for red fir-mountain hemlock forests (Bekker and Taylor, 2001). In the Caribou Wilderness the mean fire return interval between the years of 1768 and 1874 was 66 years for red fir-western white pine forest (Taylor and Solem, 2001). This forest is has a very open canopy with low fuel loads, the fire return interval seem like it would be longer than the average red fir western white pine forest. A fire return interval for this site might range from 70 to 109 years. In a separate study, Beaty and Taylor report that fire return intervals are longer on north facing slopes than on south facing slopes. Stand replacing fire is more common on the upper slopes, while low to moderate intensity fires occur only along the lower slopes. This is probably due to the tendency of fire to burn upslope, preheating the fuels as it goes. Large fires and multiple small fires in the same season are associated with dry and very dry years (Beaty and Taylor, 2001).

Evidence of fire suppression is everywhere in this forest type. Even in the most open forests, young seedlings and saplings are filling in the understory and shading out pinemat manzanita. Some areas are further along than others in understory development, with several canopy layers dominated by California red fir. As the canopy cover increases, the shade intolerant western white pine declines in the understory. Areas that still have open canopies and very little understory recruitment may have experienced fire or wind throw events. Open forests may have

microclimates that are warmer and droughtier than other areas with this site, due to aspect, slope position and/or slope shape. Therefore, tree recruitment is slower in some areas than others.

This forest is susceptible to several pathogens that can break out to epidemic levels and cause extensive stand mortality. Native pathogens are a natural component of the ecosystem and, at times, have important functions within the forest cycle. If trees are overstressed due to drought or competition for sunlight, they become more vulnerable to pests and disease. Pathogens often infest the weak trees and spread in overcrowded conditions. The surviving trees may benefit from the death of overstocked trees, and canopy gaps provide an opportunity for regeneration of the same or other species.

The major pathogens that affect California red fir in this area are red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *magnificae*), fir broom rust (*Melampsorella caryophyllacearum*), annosus root rot (*Heterobasidion annosum*), and the fir engraver (*Scolytus ventralis*) (Murphy et al., 2000). Other diseases that can affect red fir are the heart rots yellow cap fungus (*Pholiota limonella*) and Indian paint fungus (*Echinodontium tinctorium*). Insects that can affect red fir are cone maggots (*Earomyia* spp.), several chalcids (*Megastigmus* spp.) and cone moths (*Barbara* spp. and *Eucosma* spp.) (Burns, et al., 1990).

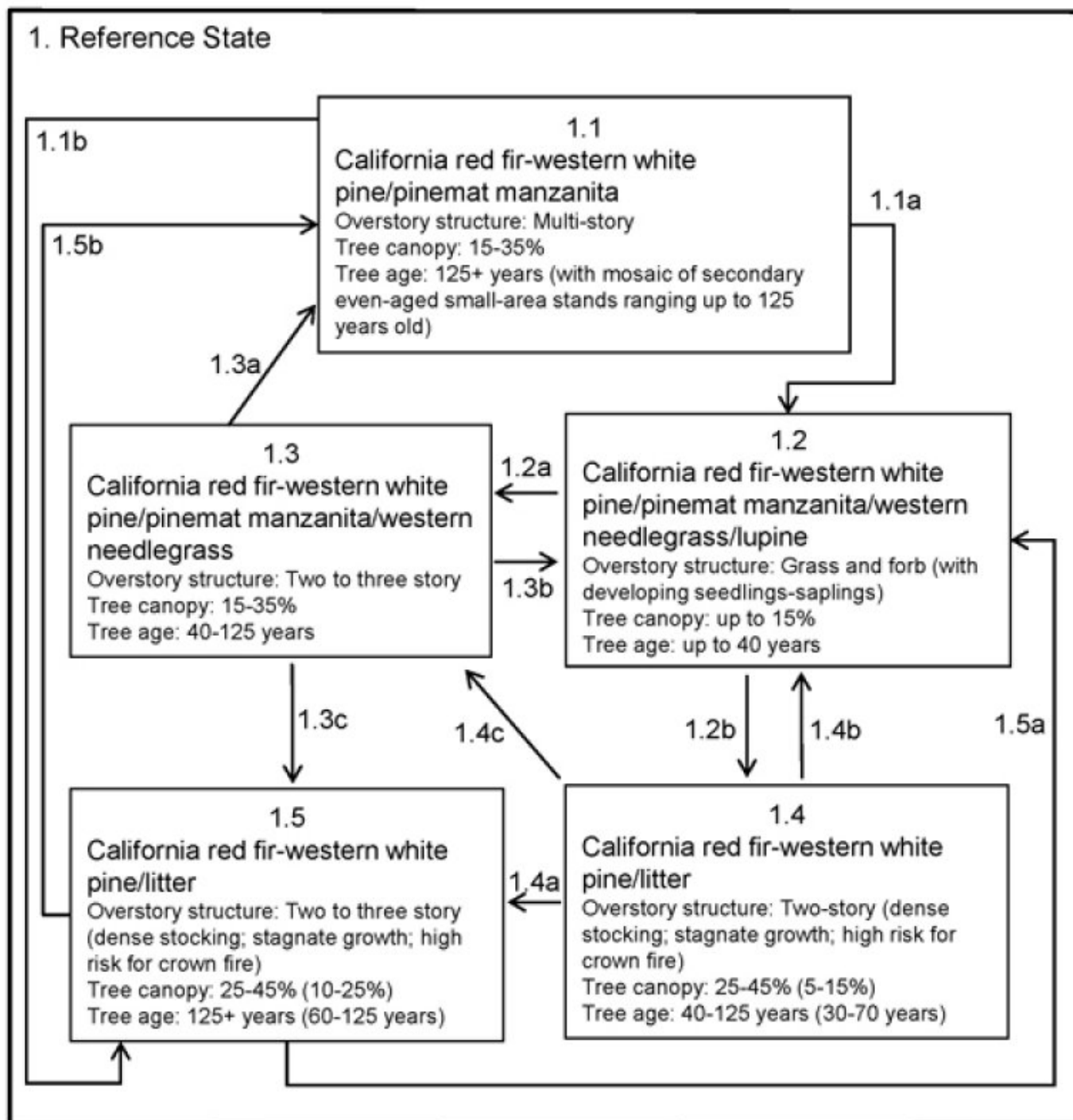
The major pathogen affecting western white pine is the white pine blister rust (*Cronartium ribicola*). It is a non-native disease that was introduced from Europe and Asia in the 1920s. The fungus causes cankers on five-needle pines that eventually kill most of the infected trees. Visible symptoms are swollen cankers with an abundance of pitch flowing down the branch or stem. The cankers can eventually girdle the tree, killing the portions above and causing the leaves to turn red and fall (Hagle et al., 2003). Pruning cankers from infected stems has shown to be beneficial. Some strains of western white pine have shown resistance to the disease. Other pathogens that affect western white pine are needle cast fungi (*Lophodermella arcuata*, *Lophodermium nitens*, and *Bifusella linearis*) and butt-rot fungi (*Phellinus pini*, *Phaeolus schweinitzii*, *Heterobasidion annosum*, and *Armillaria* spp.). Insects that can cause damage include the mountain pine beetle (*Dendroctonus ponderosae*), emarginate ips (*Ips emarginatus*), and ips beetle (*Ips montanus*) (Graham, 1990).

All tabular data listed for a specific community phase within the ecological site description represents a summary of one or more field data collection plots taken in communities within the community phase. Although such data is valuable in understanding the phase (kinds and amounts of ground and surface materials, canopy characteristics, community phase species, production and composition, and growth), it typically does not represent the absolute range of characteristics nor an exhaustive listing of species for all the dynamic communities within each specific community phase.

State and transition model

State-Transition Model - Ecological Site No. F022BI115CA

Abies magnifica-*Pinus monticola*/*Arctostaphylos nevadensis*/*Achnatherum occidentale*
(California red fir-western white pine/pinemat manzanita/western needlegrass)



State 1 Reference

Community 1.1 California red fir-western white pine/pinemat manzanita

The mature open California red fir forest is the reference community phase for this ecological site. It is similar to its historic condition, with only minor changes in understory density due to the lack of fire. A natural fire regime reflects the time it takes for a forest to naturally develop fuels sufficient to carry fire. At the upper elevations in red fir

dominated forests, fuel accumulation is slow and relatively compact, reducing flammability. Red fir seedlings develop slowly due physiographic characteristics and climatic variables, so ladder fuels take decades to develop. The natural fire return interval may be 70 to 100 years for this site. Taylor (2000) reports a significant drop in fire after 1905 on Prospect Peak, just over 100 years ago. Therefore this area is theoretically due for a fire according to the historic fire cycle, but it is not long overdue and impacts from fire suppression are minimal. Understory growth is visible in the community photo. A number of the understory trees would be killed in the event of a fire.

Forest overstory. The overstory canopy cover ranges from 15 to 35 percent, dominated by California red fir. Less than half the canopy is composed of western white pine. Sierra lodgepole pine, white fir, or mountain hemlock are occasionally present. The upper canopy height is between 90 to 120 tall, with 110 to 300 year old trees. The dbh (diameter at breast height) of the overstory trees ranges from 25 to 40 inches and basal area ranges from 50 to 80 ft2/acre.

Forest understory. The understory consists of 15 to 90 percent cover of pinemat manzanita (*Arctostaphylos nevadensis*). The diversity of species is relatively low. Other plants that may be present with low cover include western needlegrass (*Achnatherum occidentale*), greenleaf manzanita (*Arctostaphylos patula*), pioneer rockcress (*Arabis platysperma*), squirreltail (*Elymus elymoides*), scarlet gilia (*Ipomopsis aggregata*), narrowleaf lupine (*Lupinus angustifolius*), and bluntlobe lupine (*Lupinus obtusilobus*).

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	112	426	813
Forb	–	–	102
Grass/Grasslike	–	19	45
Tree	–	19	34
Total	112	464	994

Table 6. Ground cover

Tree foliar cover	15-40%
Shrub/vine/liana foliar cover	15-90%
Grass/grasslike foliar cover	0-8%
Forb foliar cover	0-15%
Non-vascular plants	0-1%
Biological crusts	0%
Litter	40-95%
Surface fragments >0.25" and <=3"	1-25%
Surface fragments >3"	7-35%
Bedrock	0-1%
Water	0%
Bare ground	0-18%

Table 7. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	—	—	0-4%	0-1%
>0.15 <= 0.3	—	15-90%	0-4%	0-1%
>0.3 <= 0.6	0-1%	—	—	0-13%
>0.6 <= 1.4	0-1%	0-5%	—	—
>1.4 <= 4	0-2%	—	—	—
>4 <= 12	1-2%	—	—	—
>12 <= 24	2-10%	—	—	—
>24 <= 37	10-30%	—	—	—
>37	—	—	—	—

Community 1.2

California red fir-western white pine/pinemat manzanita/western needlegrass/lupine

This community phase develops after a stand replacing fire or in small gaps created by a canopy disturbance. California red fir and western white pine will germinate from wind or animal dispersed seed after a fire, although California red fir seedling establishment may be delayed for 3 to 4 years. This may be due to the mortality of the seedlings during the first few years or be related to the timing of cone production, which occurs in 2 to 6 year intervals (Chappell and Agee 1996). The seeds germinate best in bare soil or in light litter, in full sun to partial shade. Initial growth of California red fir is best in dense shade, but as the seedlings get older they grow better in full sun. The winged red fir seeds are wind dispersed 1 to 1.5 times the height of the parent tree. The seeds generally germinate the spring after they are shed and are not stored in the soil. It may take 10 to 25 years for California red fir to reach 4.5 feet (Cope, 1993). The seeds of western white pine can be dispersed over 2,000 feet by wind. Seeds can remain viable in litter for up to 4 years, but viability decreases quickly (Griffith, 1992). Birds, squirrels and other rodents will cache some of these seeds in the soil, which may germinate in bunches if not consumed. The severity and size of a fire influence the structure of regeneration. California red fir seems to regenerate better after a low to moderate intensity fire, or in high intensity fires of smaller size. This is most likely due to proximity to a seed source and the benefits from partial shade (Chappell and Agee 1996). Pinemat manzanita is killed by fire. It does not resprout from the root crown but re-establishes itself from seed. It colonizes disturbed sites and continues to grow well under an open canopy as long as there is sufficient sunlight (Howard, 1993). Other forbs and grasses germinate from on-site stored seed or wind dispersed seed from adjacent areas. Some of the understory species may resprout after low to moderate intensity fires.

Community 1.3

California red fir-western white pine/pinemat manzanita/western needlegrass

California red fir and western white pine continue to grow into an open forest due to the natural preference of sunlight and the occasional lightening induced surface fire. This community phase experiences rapid growth in conifer height and canopy cover. California red fir can reach seed bearing age at 35 to 40 years, but western white pine can bear seed at 10 years (Cope, 1993, and Griffith, 1992). Therefore California red fir needs a longer fire free interval to develop new seed crops. This community phase begins with pole-sized trees and lasts until the trees are about 100 years old. California red fir will slowly continue to regenerate under the forest canopy during this time.

Community 1.4

California red fir-western white pine/litter

The development of this community phase within this ecological site is relatively uncommon since young even aged dense stands generally do not form, due to poor forest productivity. Dense stands seem to form more often through pathway 1.1b, from increased understory growth under the mature open canopy. This forest develops after a period of forest regeneration. The trees may be pole-sized and even aged at first, but will develop into a mature forest over time. Density increases as California red fir and western white pine continue to establish in the understory, creating multiple canopy layers. When this forest develops it is defined by a dense canopy and high basal area of California red fir and, to a lesser degree, western white pine. Canopy cover ranges from 30 to 60 percent. The overstory trees

may be up to 125 years old. The trees are overcrowded and often diseased and stressed due to competition for water and nutrients. This stress makes the trees more susceptible to death from infestation and drought. Fire hazard increases in this community, a result of the deep accumulation of litter, standing dead and down trees, and the dense multi-layered structure of the forest.

Community 1.5

California red fir-western white pine/pinemat manzanita

The mature closed California red fir forest develops with the continued exclusion of fire, allowing tree density to increase to unhealthy levels. Competition for water and sunlight continue, and tree health and vigor decreases. The overstory trees are over 125 years old. As mentioned above, the dense community phase is usually reached by community pathway 1.1b, with tree density increasing from the development of the understory under the mature open canopy.

Forest overstory. The canopy cover ranges from 35 to 60 percent with an average of about 50 percent. California red fir is dominant, with western white pine composing about a third of the overstory. The overstory trees are 100 to 120 feet tall with a mid-canopy layer around 60 to 80 feet. Basal area ranges from 110 to 180 ft²/acre.

Forest understory. Pinemat manzanita is still the dominant understory vegetation, but cover has reduced to 2 to 40 percent. Other species mentioned in Community 1.1 may be present in trace amounts. California red fir seedlings and saplings have about 10 percent cover. Western white pine is regenerating as well, and may have 0 to 8 percent cover.

Pathway 1.1a

Community 1.1 to 1.2

Wind throw, fire, or tree die off from disease creates openings in the forest that present suitable conditions for California red fir and western white pine regeneration (Community Phase 1.2).

Pathway 1.1b

Community 1.1 to 1.5

If fire is excluded from the old growth community phase, tree density continues to increase in the understory and shifts the community phase toward the closed California red fir forest (Community Phase 1.5).

Pathway 1.2a

Community 1.2 to 1.3

The natural pathway is to Community Phase 1.3, the young open California red fir forest. This pathway is followed in time and growth with small low to moderate intensity surface fires.

Pathway 1.2b

Community 1.2 to 1.4

An alternate pathway is created when fire is excluded from the system and leads to the Young Closed California red fir forest (Community Phase 1.4). This pathway is unlikely given the natural tendency for this site to maintain an open canopy, even in the absence of fire for 70 years or more. However, if seed is available and soil moisture and climatic conditions are favorable for seedling survival, a dense even aged forest could develop.

Pathway 1.3a

Community 1.3 to 1.1

This is the natural pathway for this community phase, which evolved with a historic fire regime of small low to moderate intensity surface fires, and/or partial tree mortality from a pest outbreak. This pathway leads to a mature open California red fir forest (Community Phase 1.1).

Pathway 1.3b

Community 1.3 to 1.2

In the event of a canopy fire this community phase would return to Community Phase 1.2, Stand Regeneration.

Pathway 1.3c

Community 1.3 to 1.5

If fire does not occur, forest density increases. The increased density shifts this community phase toward the closed California red fir forest (Community Phase 1.5).

Pathway 1.4b

Community 1.4 to 1.2

At this point the density of ground fuels and ladder fuels formed in the mid-canopy create conditions for a high intensity canopy fire. A severe fire would initiate conifer regeneration (Community Phase 1.2).

Pathway 1.4c

Community 1.4 to 1.3

The natural event of a moderate or surface fire in this forest is unlikely due to the high accumulation of fuels. Considerable management efforts would be needed to create the open forest conditions that should exist in this forest had it had developed with fire over time. Manual treatments to thin out the trees and fuels in the understory, and/or prescribed burns, could be implemented to shift this forest back to its natural state of an open California red fir-western white pine forest (Community Phase 1.3). A partial mortality disease or pest infestation could also create a shift toward Community Phase 1.3.

Pathway 1.4a

Community 1.4 to 1.5

If fire continues to be excluded from this system the mature closed California red fir forest develops (Community Phase 1.5).

Pathway 1.5b

Community 1.5 to 1.1

The natural event of a moderate or surface fire in this forest is unlikely due to the high accumulation of fuels. Considerable management efforts would be needed to create the open forest conditions that should exist in this forest had it had developed with fire over time. Manual treatments to thin out the understory trees and other fuels, and/or prescribed burns, could be implemented to shift this forest back to its natural state of an open California red fir-western white pine forest (Community Phase 1.1). A partial mortality disease or pest infestation could also create a shift toward Community Phase 1.1.

Pathway 1.5a

Community 1.5 to 1.2

At this point a severe fire is likely and would initiate conifer regeneration (Community Phase 1.2).

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Tree					
0	Tree (understory only)			0–34	
	California red fir	ABMA	<i>Abies magnifica</i>	0–22	0–4
	western white pine	PIMO3	<i>Pinus monticola</i>	0–9	0–3
	Sierra lodgepole pine	PICOM	<i>Pinus contorta var. murrayana</i>	0–2	0–1
Shrub/Vine					
0	Shrub			112–813	
	pinemat manzanita	ARNE	<i>Arctostaphylos nevadensis</i>	112–673	15–90
	greenleaf manzanita	ARPA6	<i>Arctostaphylos patula</i>	0–112	0–5
	bush chinquapin	CHSE11	<i>Chrysolepis sempervirens</i>	0–28	0–2
Grass/Grasslike					
0	Grass/Grasslike			0–45	
	squirreltail	ELEL5	<i>Elymus elymoides</i>	0–22	0–5
	western needlegrass	ACOC3	<i>Achnatherum occidentale</i>	0–17	0–5
	Ross' sedge	CARO5	<i>Carex rossii</i>	0–6	0–1
Forb					
0	Forb			0–102	
	bluntlobe lupine	LUOB	<i>Lupinus obtusilobus</i>	0–54	0–5
	narrowleaf lupine	LUAN4	<i>Lupinus angustifolius</i>	0–28	0–3
	scarlet gilia	IPAG	<i>Ipomopsis aggregata</i>	0–19	0–10
	pioneer rockcress	ARPL	<i>Arabis platysperma</i>	0–1	0–1

Table 9. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
California red fir	ABMA	<i>Abies magnifica</i>	Native	–	10–20	–	–
western white pine	PIMO3	<i>Pinus monticola</i>	Native	–	5–13	–	–
Sierra lodgepole pine	PICOM	<i>Pinus contorta var. murrayana</i>	Native	–	0–2	–	–

Table 10. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
western needlegrass	ACOC3	<i>Achnatherum occidentale</i>	Native	–	0–5
squirreltail	ELEL5	<i>Elymus elymoides</i>	Native	–	0–5
Ross' sedge	CAR05	<i>Carex rossii</i>	Native	–	0–1
Forb/Herb					
scarlet gilia	IPAG	<i>Ipomopsis aggregata</i>	Native	–	0–10
bluntlobe lupine	LUOB	<i>Lupinus obtusilobus</i>	Native	–	0–5
narrowleaf lupine	LUAN4	<i>Lupinus angustifolius</i>	Native	–	0–3
pioneer rockcress	ARPL	<i>Arabis platysperma</i>	Native	–	0–1
Shrub/Subshrub					
pinemat manzanita	ARNE	<i>Arctostaphylos nevadensis</i>	Native	–	15–90
greenleaf manzanita	ARPA6	<i>Arctostaphylos patula</i>	Native	–	0–5
bush chinquapin	CHSE11	<i>Chrysolepis sempervirens</i>	Native	–	0–2
Tree					
California red fir	ABMA	<i>Abies magnifica</i>	Native	–	0–4
western white pine	PIMO3	<i>Pinus monticola</i>	Native	–	0–3
Sierra lodgepole pine	PICOM	<i>Pinus contorta</i> var. <i>murrayana</i>	Native	–	0–1

Table 11. Community 1.5 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
California red fir	ABMA	<i>Abies magnifica</i>	Native	–	25–40	–	–
western white pine	PIMO3	<i>Pinus monticola</i>	Native	–	10–20	–	–

Table 12. Community 1.5 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Shrub/Subshrub					
pinemat manzanita	ARNE	<i>Arctostaphylos nevadensis</i>	Native	–	2–40
Tree					
California red fir	ABMA	<i>Abies magnifica</i>	Native	–	5–15
western white pine	PIMO3	<i>Pinus monticola</i>	Native	–	0–8

Animal community

Animals that use California red fir forests include martin, fisher, wolverine, black bear, squirrel, chickadee, pileated woodpecker, great gray owl, Williamson's sapsucker, mountain beaver, and pocket gopher.

Deer browse the new growth of conifers in the spring. Birds forage for insects in the foliage of mature conifers. Spruce grouse feed on Sierra lodgepole pine needles during the winter (Cope, 1993).

The California red fir cones are cut and cached by squirrels. Western white pine seeds are eaten by red squirrels and deer mice (Griffith, 1992). The seeds of Sierra lodgepole pine are eaten by squirrels, chipmunks, birds, and mice (Cope, 1993).

The fruit of pinemat manzanita is eaten by black bear, deer, coyote, and various birds and rodents. Young foliage after fire is browsed by deer, but older foliage is not desirable.

The grasses provide forage for deer and small rodents.

Recreational uses

This site is suitable for trails and provides excellent views.

Wood products

The wood from California red fir is straight-grained and light. California red fir is soft but stronger than the wood of other firs, and has a low specific gravity. The wood is used for fuel, coarse lumber, quality veneer, solid framing, plywood, printing paper, high-quality wrapping paper, and is preferred for pulping (Cope, 1993).

Western white pine wood is straight-grained, light, and highly valued. The wood is used to make window and door sashes, doors, paneling, dimension stock, matches, wood carvings and toothpicks (Griffin, 1992).

Other products

California red fir is used for Christmas trees (Cope, 1993).

Native Americans chewed the resin of western white pine, wove baskets from the bark, concocted a poultice for dressing wounds from the pitch, and collected the cambium in the spring for food (Griffith, 1992).

Cones of western white pine are collected for novelty items. The wood is good for carving. The tree is also planted as an ornamental (Griffin, 1992).

Other information

Forest Pathogens:

The parasitic red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *magnificae*) is common in the survey area, as evident by witches brooms, top kill, stem cancers and swellings. The vegetative shoots of the dwarf mistletoe are often present from spring to fall. Infestation of the red fir dwarf mistletoe can cause reduced growth and vigor. A fungus, (*Cytospora abietis*), kills the branches that are infected with dwarf mistletoe. Dwarf mistletoe weakens the tree and allows other pathogens to infest the tree. The mistletoe cankers create an entry point for other diseases, such as heart rots (Burns, et al., 1990).

Fir broom rust (*Melampsorella caryophyllacearum*) is a disease that causes dense witches brooms with stunted yellow needles. The infected branch sheds its needles in fall, leaving a barren dead looking branch. The alternate host for this rust is the chickweeds (*Stellaria* spp. and *Cerastium* spp.) (Hagle et al., 2003). This disease can damage tree growth by reducing crown development. Mortality is less common in mature trees than in younger regeneration trees.

Annosus root rot (*Heterobasidion annosum*) can affect large acres of fir forest. It spreads from infected roots to healthy roots. It slowly decays the roots, the root collar and the stem butt for many years, causing structural weaknesses and making the tree vulnerable to wind throw. Annosus root rot can also be spread aerially, infecting freshly cut stumps or other fresh tree wounds. Painting borax on freshly cut stumps restricts the entry of the fungus. In all management activities, it is important to reduce damage to the bark. The rot itself does not often kill red fir directly, but it weakens the tree and makes it easier for bark beetles (*Scolytus* spp.) to infest the tree (Burns, et al., 1990).

The fir engraver (*Scolytus ventralis*) can cause extensive damage to red fir forests and outbreaks can cause mortality to several acres of trees. It can reach epidemic levels when trees are stressed due to drought, annosus root rot, dwarf mistletoe, or from fire damage. (Burns, et al., 1990).

SITE INDEX DOCUMENTATION:

Schumacher (1928), Haig (1932), and Alexander (1966) were used to determine forest site productivity for red fir, western white pine, and Sierra lodgepole pine respectively. Low to High values of Site index and CMAI (culmination of mean annual increment) give an indication of the range of inherent productivity of this ecological site. Site index relates to height of dominant trees over a set period of time and CMAI relates to the average annual growth of wood fiber in the boles/trunks of trees. Site index and CMAI listed in the Forest Site Productivity section are in units of feet and cubic feet/acre/year, respectively. Both site index and CMAI are estimates; on-site investigation is recommended for specific forest management units for each soil classified to this ecological site. The historical and actual basal area of trees within a growing stand will greatly influence CMAI. Conifer trees appropriate for site index measurement typically occur in community phases 1.3 and 1.4. They are selected according to guidance listed in the site index publications.

Table 13. Representative site productivity

Common Name	Symbol	Site Index Low	Site Index High	CMAI Low	CMAI High	Age Of CMAI	Site Index Curve Code	Site Index Curve Basis	Citation
California red fir	ABMA	34	45	116	153	140	050	—	
California red fir	ABMA	34	45	116	153	—	—	50TA	Haig, Irvine T. 1932. Second-growth yield, stand, and volume tables for the western white pine type. USDA, Forest Service. Northern Rocky Mountain Forest Experiment Station Technical Bulletin 323.
western white pine	PIMO3	38	46	81	94	100	570	—	
western white pine	PIMO3	38	46	81	94	—	—	50TA	Haig, Irvine T. 1932. Second-growth yield, stand, and volume tables for the western white pine type. USDA, Forest Service. Northern Rocky Mountain Forest Experiment Station Technical Bulletin 323.
Sierra lodgepole pine	PICOM	60	68	49	66	100	520	—	
Sierra lodgepole pine	PICOM	60	68	50	57	—	—	50TA	Haig, Irvine T. 1932. Second-growth yield, stand, and volume tables for the western white pine type. USDA, Forest Service. Northern Rocky Mountain Forest Experiment Station Technical Bulletin 323.

Inventory data references

The following NRCS vegetation plots were used to describe this ecological site:

789174
789187- site location
789189
789209
789226
789229
789231
789255
789321
789355
789356
789360

Type locality

Location 1: Shasta County, CA

Township/Range/Section	T31 N R5 E S35
UTM zone	N
UTM northing	4484530
UTM easting	636025
General legal description	The type location is about 0.75 miles east of the base of Hat Mountain in Lassen Volcanic National Park.

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Contributors

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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	
Approved by	
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:**
