USDA Natural Resources Conservation Service

Ecological site F022BI113CA
Frigid Very Deep Loamy Slopes

Accessed: 05/13/2025

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: Mountain slope
Elevation (feet): 5,680-8,570
Slope (percent): 10-80, but generally 10 to 50
Water Table Depth (inches): n/a
Flooding-Frequency: None
Ponding-Frequency: None
Aspect: South, East, West
Mean annual precipitation (inches): 63.0-119.0
Primary precipitation: Winter months in the form of snow
Mean annual temperature: 38 and 42 degrees F (3.3 to 5.5 degrees C)
Restrictive Layer: Paralithic contact occurs below 60 inches
Temperature Regime: Frigid
Moisture Regime: Xeric
Parent Materials: Tephra and colluvium over residuum from hydrothermally altered rocks
Surface Texture: Ashy Loam
Surface Fragments <=3" (% Cover): 8-40
Surface Fragments > 3" (% Cover): 0-1

Soil Depth (inches): 60
Vegetation: Heavily dominated by California red fir (*Abies magnifica*) with an occasional western white pine (*Pinus monticola*) and mountain hemlock (*Tsuga mertensiana*). White fir (*Abies concolor*) is found at the lower elevations with California red fir. Associated understory species include spreading phlox (*Phlox diffusa*), mountain monardella (*Monardella odoratissima*), ragwort (Senecio spp.), bluntlobe lupine (*Lupinus obtusilobus*), woolly mule-ears (*Wyethia mollis*), dusky onion (*Allium campanulatum*), and pinemat manzanita (*Arctostaphylos nevadensis*).
Notes: This ecological site occurs on mountain slopes in the hydrothermally altered areas of Brokeoff Volcano.

Classification relationships

Forest Alliance = *Abies magnifica* - Red fir forest; Association = (no matching species). (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

R022BI203CA	**Moderately Deep Fragmental Slopes** This rangeland ecological site is dominated by woolly mule-ears.
R022BI209CA	**Loamy Seeps** This is a wet rangeland site associates with seeps and springs.
R022BI216CA	**Active Hydrothermal Areas (Complex)** This site is actively eroding and moving, with changing vegetation.

Similar sites

F022BI118CA	**Frigid Landslide Undulating Slopes** This is a dense red fir forest on landslides in hydrothermally altered material.
F022BI114CA	**Frigid Very Deep Cinder Cone Or Shield Volcano Slopes** This is an open red fir-western white pine forest on volcanic rubble.
F022BI115CA	**Frigid And Cryic Gravelly Slopes** This is an open California red fir-western white pine forest with high cover of pinemat manzanita.

Table 1. Dominant plant species

Tree	(1) *Abies magnifica*
Shrub	Not specified
Herbaceous	(1) *Monardella odoratissima* (2) *Phlox diffusa*

Physiographic features

This ecological site occurs on mountain slopes in the hydrothermally altered areas of Brokeoff Volcano. This site is found between 5,680-8,570 feet in elevation. Slopes range from 10 to 80 percent, but are generally between 10 to 50 percent.

Table 2. Representative physiographic features

Landforms	(1) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	1,731–2,591 m
Slope	10–80%
Aspect	E, S, W

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 63 to 119 inches (1,600 to 3,023 mm) and the mean annual temperature is between 38 and 42 degrees F (3.3 to 5.5 degrees C). The frost free (>32 degree F) season is 60 to 85 days. The freeze free (>28 degrees F) season is 75 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)	3,023 mm

Influencing water features

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

Soil features

The Diamondpeak soil series is associated with this site. Diamondpeak soils are very deep and well drained. They formed in tephra and colluvium over residuum from hydrothermally altered rocks. Acidic steam and water of various temperatures and pH have altered the mineralogy of the rock to produce soils with a significantly higher amount of clay and a lower pH than those soils in the rest of the Park. The pH was sampled in the field at 4.7 at depths from 0 to 3 inches, and 5.0 to 5.1 in the lower horizons. These soils are strongly acidic and have high levels of aluminum and manganese. The soil lab report indicates levels of aluminum and manganese that could cause toxicity in plants. Aluminum +++ becomes soluble in acidic soils and impairs root growth, reducing the plant’s ability to access water. Plants with aluminum toxicity may show symptoms of phosphorus (P), calcium (Ca), and magnesium (Mg) deficiencies due to the low pH. Manganese toxicity is also associated with acidic soils. The symptoms of manganese toxicity are reduced shoot growth, discoloring and chlorosis of leaves.

The Diamondpeak soils are classified as Fine-loamy, isotic, frigid Typic Dystroxerepts. The surface texture in the A horizon from 0 to 3 inches is an ashy loam. The subsurface textures are (with increasing depth) very paragravelly clay loam, very paragravelly sandy clay loam, and extremely paragravelly loam. Paragravel content increases with depth from 50 to 75 percent. The A horizon has 25 percent clay, with 39 percent clay in the horizon below. Percent clay gradually decreases with depth, with 18 percent clay at 60 inches. Paralithic contact occurs below 60 inches. Permeability ranges from rapid to moderately slow throughout the profile.

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

Map Unit Component, Component %
119 Diamondpeak, 30

Table 4. Representative soil features

Surface texture	(1) Ashy loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Rapid to moderately slow
Soil depth	152 cm
Surface fragment cover <=3"	8–40%

Surface fragment cover >3"	0–1%
Available water capacity (0-101.6cm)	24.18–28.04 cm
Soil reaction (1:1 water) (0-101.6cm)	4.5–6
Subsurface fragment volume <=3" (Depth not specified)	4–75%
Subsurface fragment volume >3" (Depth not specified)	0–1%

Ecological dynamics

This forest is heavily dominated by California red fir (*Abies magnifica*) with an occasional western white pine (*Pinus monticola*) and mountain hemlock (*Tsuga mertensiana*). White fir (*Abies concolor*) is found at the lower elevations with California red fir. The overstory tree canopy ranges from 10 to 50 percent. The forest is patchy and unevenly aged. Associated understory species include spreading phlox (*Phlox diffusa*), mountain monardella (*Monardella odoratissima*), ragwort (Senecio spp.), bluntlobe lupine (*Lupinus obtusilobus*), woolly mule-ears (*Wyethia mollis*), dusky onion (*Allium campanulatum*), and pinemat manzanita (*Arctostaphylos nevadensis*).

The soils are unique to this area because of a high clay content, low pH, and potentially toxic levels of aluminum and manganese. In addition to the inherent properties of the soil, there may be ongoing chemical deposition from the active hydrothermal vents and bare areas. Deposition can sometimes be seen as a yellow coating on the snow, which can affect surface pH and mineralogy. Hydrogen sulfide (H2S), carbon dioxide (CO2), hydrogen gas (H2), nitrogen (N), and helium (He) are some of the chemicals found in the thermal springs. They react with oxygen and other elements to form the variety of chemicals that can be found in the steam deposits.

California red fir has a high site index potential on this soil but in most areas still remains an uneven aged open forest. Trees may have difficulty establishing at first but once established, will grow well. Low pH, potential Al and Mn toxicity, open sun and low litter accumulation may all combine to contribute to poor seedling establishment. Understory composition and production may be influenced by the chemical characteristics of the soil as well. Pinemat manzanita (*Arctostaphylos nevadensis*) is common in open red fir forest nearby, but is not extensive in this area.

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 needles 0.8 to 1.4 inches in length 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 occasionally present. Western white pine is also a long lived conifer with narrow crowns. 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 high 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 type 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 then for 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). The stand densities and fuel characteristics of the forests in these studies are not specific enough to directly compare to fire return intervals for this site, but it seems likely that this ecological site is more open than the red fir-white fir forests on Prospect Peak or in Thousand Lakes Wilderness, so the fire return interval may lean toward the longer interval of 70 years or more. 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).

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 the overstocked trees, and canopy gaps provide an opportunity for regeneration of the same or other species.

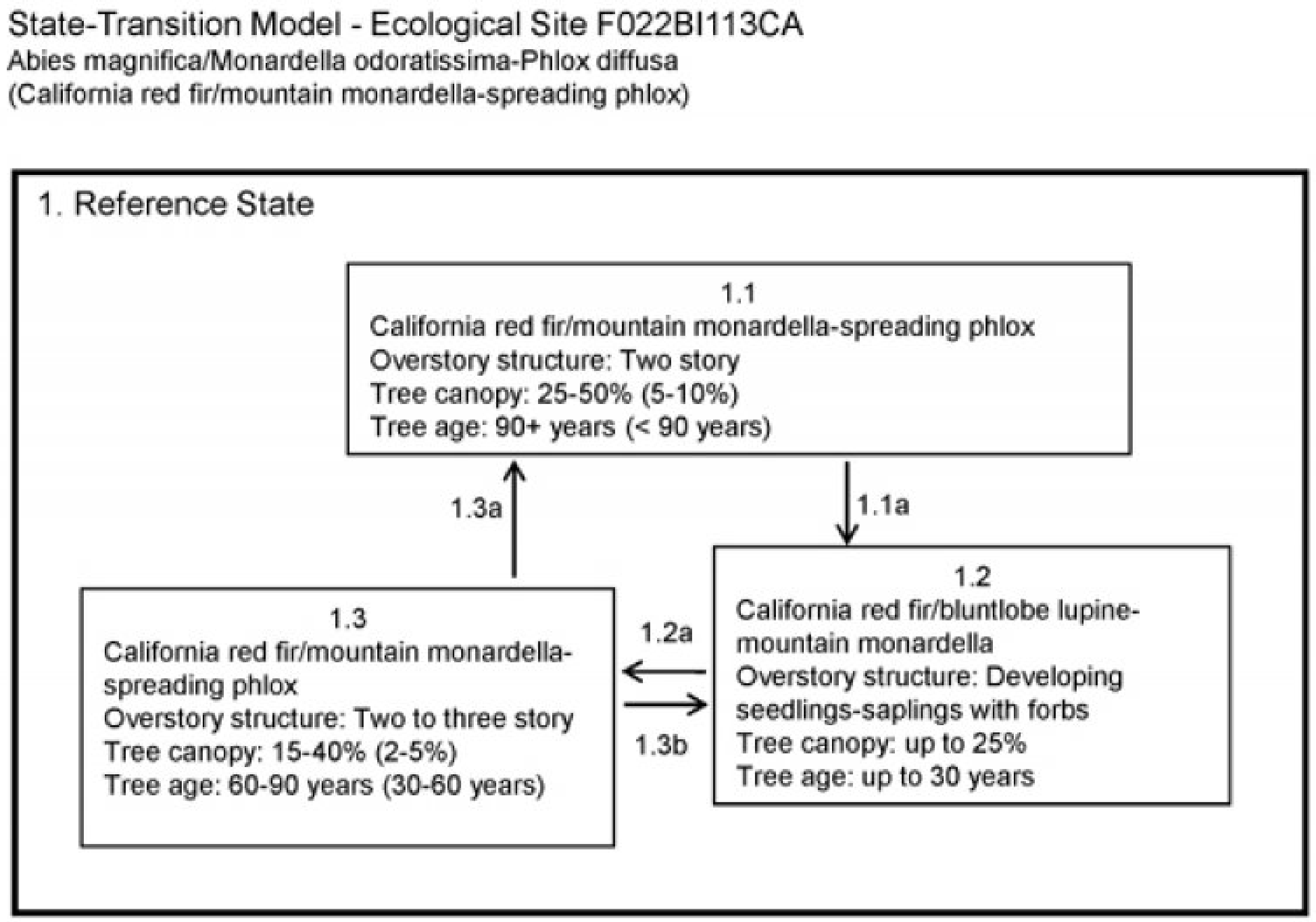
The major pathogens that affect California red fir in this area are red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. magnificae), fir broom rust (Melampsorella caryophyllacearum), annosus root rot (Heterobasidion annosum), and the fir engraver (Scolytus ventralis) (Murphy et al., 2000). Other 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 upper portions above and causing 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).

The reference state consists of the most successionally advanced community phase (numbered 1.1) as well as other community phases which result from natural and human disturbances. Community phase 1.1 is deemed the phase representative of the most successionally advanced pre-European plant/animal community including periodic natural surface fires that influenced its composition and production. Because this phase is determined from the oldest modern day remnant forests and/or historic literature, some speculation is necessarily involved in describing it.

All tabular data listed for a specific community phase within this ecological site description represent a summary of one or more field data collection plots taken in communities within the community phase. Although such data are valuable in understanding the phase (kinds and amounts of ground and surface materials, canopy characteristics, community phase overstory and understory 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 1
Reference

Community 1.1
California red fir/mountain monardella-spreading phlox

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 elevation red fir dominated forests, fuel accumulation is slow and relatively compact, reducing flammability. Red fir seedlings develop slowly due to physiographic characteristics and climatic variables, so ladder fuels take decades to develop. The natural fire return interval may be more than 100 years for this site. Taylor reports a significant drop in fire after 1905, just over 100 years ago (Taylor, 2000). 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.

Forest overstory. California red fir heavily dominates this forest with a few other conifers, including western white pine and mountain hemlock. There are several canopy layers as trees slowly recruit into the understory. The height of the upper tree canopies range from 100 to 130 feet and trees are 90 to greater than 200 years old. The dbh (diameter at breast height) of the mature trees ranges from 30 to 45 inches. Below the oldest trees is another canopy 60 to 80 feet tall, with 55 to 70 year old trees. Dbh ranges from 15 to 22 inches. Basal area ranges from 200 to 280 ft2/ acre. Tree canopy cover ranges from 25 to 50 percent.

Forest understory. The understory is generally sparse, but increases in some areas where tree canopy is low and conditions are suitable for growth. There is a 10 percent cover from dusky onion (Allium campanulatum) at this site, which is unusually high. Other common plants are pinemat manzanita (Arctostaphylos nevadensis), bluntlobe lupine (Lupinus obtusilobus), mountain monardella (Monardella odoratissima), spreading phlox (Phlox diffusa) and woolly mule-ears (Wyethia mollis).

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Forb	8	27	67
Shrub/Vine	6	22	41
Tree	–	9	17
Total	**14**	**58**	**125**

Table 6. Ground cover

Tree foliar cover	25-50%
Shrub/vine/liana foliar cover	0-2%
Grass/grasslike foliar cover	0%
Forb foliar cover	5-25%
Non-vascular plants	0%
Biological crusts	0%
Litter	30-80%
Surface fragments >0.25" and <=3"	8-45%
Surface fragments >3"	0-5%
Bedrock	0%
Water	0%
Bare ground	0-10%

Community 1.2
California red fir/bluntlobe lupine-mountain monardella

This community phase develops after a stand replacing fire or in small gaps created by a canopy disturbance. California red fir will germinate from wind or animal dispersed seed after a fire. California red fir seedling establishment may be delayed for 3 to 4 years after a fire. 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) or longer on this site. Birds, squirrels and other rodents will cache some of these seeds in the soil, where they may germinate in bunches if not consumed. The severity and size of 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). There may be an increase in understory cover after a fire, but grasses are not common in this area. Bluntlobe lupine (*Lupinus obtusilobus*), mountain monardella (*Monardella odoratissima*), spreading phlox (*Phlox diffusa*), woolly mule-ears (*Wyethia mollis*), dusky onion (*Allium campanulatum*), and pinemat manzanita (*Arctostaphylos nevadensis*) would most likely be top-killed by low to moderate intensity fires, although some may be able to resprout. More likely regeneration would occur from on-site or off-site seed sources.

Community 1.3
California red fir/mountain monardella-spreading phlox

California red fir continues to grow as an open forest in this area. This may be partly due to low pH and Al and Mn toxicity. An occasional lightening induced surface fire will also maintain an open forest. This community phase experiences rapid growth in conifer height and an increase in canopy cover. California red fir reaches seed bearing age at between 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.

Pathway 1.1a
Community 1.1 to 1.2

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

Pathway 1.2a
Community 1.2 to 1.3

This is 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 1.3a
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.

Additional community tables

Table 7. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Tree					
0	**Tree (understory only)**			0–17	
	California red fir	ABMA	*Abies magnifica*	0–17	0–2
Shrub/Vine					
0	**Shrub**			6–41	
	pinemat manzanita	ARNE	*Arctostaphylos nevadensis*	0–22	0–2
	mountain monardella	MOOD	*Monardella odoratissima*	6–17	2–5
	spreading phlox	PHDI3	*Phlox diffusa*	0–2	0–1
Forb					
0	**Forb**			8–67	
	bluntlobe lupine	LUOB	*Lupinus obtusilobus*	6–39	2–10
	dusky onion	ALCA2	*Allium campanulatum*	2–22	1–10
	woolly mule-ears	WYMO	*Wyethia mollis*	0–6	0–1

Table 8. 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	*Abies magnifica*	Native	–	23–45	–	–
mountain hemlock	TSME	*Tsuga mertensiana*	Native	–	0–3	–	–
western white pine	PIMO3	*Pinus monticola*	Native	–	1–2	–	–

Table 9. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Forb/Herb					
dusky onion	ALCA2	*Allium campanulatum*	Native	–	1–10
bluntlobe lupine	LUOB	*Lupinus obtusilobus*	Native	–	2–10
woolly mule-ears	WYMO	*Wyethia mollis*	Native	–	0–1
Fern/fern ally					
spreading phlox	PHDI3	*Phlox diffusa*	Native	–	0–1
Shrub/Subshrub					
mountain monardella	MOOD	*Monardella odoratissima*	Native	–	2–5
pinemat manzanita	ARNE	*Arctostaphylos nevadensis*	Native	–	0–2
Tree					
California red fir	ABMA	*Abies magnifica*	Native	–	0–2

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 area provides excellent views of geothermal processes.

Wood products

The wood from California red fir is straight-grained and light. California red fir is soft, but it’s 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).

Other products

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

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 forests. 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) was used to determine forest site productivity for red fir. 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 youngest stands in 1.1. They are selected according to guidance listed in the site index publication.

Table 10. 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*	60	60	214	214	140	050	–	
California red fir	*ABMA*	60	60	214	214	–	–	50TA	Schumacher, Francis X. 1928. Yield, stand and volume tables for red fir in California. University of California Agricultural Experiment Station Bulletin 456.

Inventory data references

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

789176
789210- site location

Type locality

Location 1: Shasta County, CA	
Township/Range/Section	T30 N R4 E S15
UTM zone	N
UTM northing	4479581
UTM easting	624796
General legal description	The type location is about 0.7 miles north-northwest of Diamond Peak, in Lassen Volcanic National Park.

Other references

Beaty, Matthew and Taylor, Alan H. (2001). Spatial and Temporal Variation of Fire Regimes in a Mixed Conifer Forest Landscape, Southern Cascades, California, USA. Journal of Biogeography, 28, 955-966.

Bekker, Mathew F. and Taylor, Alan H. (2001). Gradient Analysis of Fire Regimes in Montane Forest of the Southern Cascade Range, Thousand Lakes Wilderness, California, USA. Plant Ecology 155: 15-23.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p.

Chappell, Christopher B. and Agee, James K, 1996. Fire Severity and Tree Seedling Establishment in Abies Magnifica Forests, Southern Cascades, Oregon. Ecological Applications, Vol. 6, No. 2. (May, 1996), pp. 628-640.

Cope, Amy B. 1993. *Abies magnifica*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer).
Available: http://www.fs.fed.us/database/feis/ [2009, April 23].

Graham, Russell T. *Pinus monticola* Western White Pine. In: Silvics of North America, Volume 1. Conifers. U.S

Department of Agriculture, Forest Service, Agricultural Handbook 654. p.385-393.

Griffith, Randy Scott. 1992. *Pinus monticola*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2009, April 23].

Hagle, Susan K.; Gibson, Kenneth E.; Tunnock, Scott 2003. Field Guide to Diseases and Insect Pests of Northern and Central Rocky Mountain Conifers. U.S. Department of Agriculture, Forest Service, State and Private Forestry, Intermountain Region.

Haig 1932, Western White Pine. USDA Tech. bul. 323. NASIS ID 570

Howard, Janet L. 1993. *Arctostaphylos nevadensis*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2009, April 23].

Kilgore, Bruce M. 1981. Fire in ecosystem distribution and structure: western forests and scrublands. In: Mooney, H. A.; Bonnicksen, T. M.; Christensen, N. L.; [and others], technical coordinators. Proceedings of the conference: Fire regimes and ecosystem properties; 1978 December 11-15; Honolulu, HI. Gen. Tech. Rep. WO-26. Washington, DC: U.S. Department of Agriculture, Forest Service: 58-89.

Laacke, Robert J. *Abies magnifica* California Red Fir. In: Silvics of North America, Volume 1. Conifers. U.S Department of Agriculture, Forest Service, Agricultural Handbook 654. pp.71-77.

Parker, Albert J., 1995. Comparative Gradient Structure and Forest Cover Types in Lassen Volcanic and Yosemite National Parks, California. Bulletin of the Torrey Botanical Club, Vol. 122, No. 1. (Jan. - Mar., 1995), pp. 58-68.

Parker, Albert J., 1991. Forest/Environment Relationships in Lassen Volcanic National Park, California, U.S.A. Journal of Biogeography, Vol. 18, No. 5. (Sep., 1991), pp. 543-552.

Potter, Donald A. (1998). Forested Communities of the Upper Montane in the Central and Southern Sierra Nevada. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, General Technical Report PSW-GTR-169.

Royce, E. B. and Barbour, M. G., 2001.Mediterranean Climate Effects. I. Conifer Water Use Across a Sierra Nevada Ecotone. American Journal of Botany 88(5): 911–918. 2001.

Royce, E. B. and Barbour, M. G., 2001. Mediterranean Climate Effects. II. Conifer Growth Phenology Across a Sierra Nevada Ecotone. American Journal of Botany 88(5): 919–932. 2001.

Schumacher, Francis X. 1928. Yield, stand and volume tables for red fir in California. University of California Agricultural Experiment Station Bulletin 456. NASIS ID 050

Taylor, A. H. (2000). Fire Regimes and Forest Changes in Mid and Upper Montane Forest of the Southern Cascades, Lassen Volcanic National Park, California, U.S.A. Journal of Biogeography, 27, 87-104.

Taylor, Alan H. and Halpern, Charles B., 1991. The structure and dynamics of *Abies magnifica* forests in the southern Cascade Range, USA. Journal of Vegetation Science. 2(2): 189-200. [15768]

Taylor, Alan H. and Solem, Michael N., 2001. Fire Regimes and Stand Dynamics in an Upper Montane Forest Landscape in the Southern Cascades, Caribou Wilderness, California. Journal of the Torrey Botanical Society, Vol. 128, No. 4. (Oct. - Dec., 2001), pp. 350-361.

Contributors

Lyn Townsend
Marchel M. Munnecke

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:**
