

Ecological site F022AC005CA

Cryic Sheltered, Moist Sandy Mountain Slopes

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General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

MLRA notes

Major Land Resource Area (MLRA): 022A–Sierra Nevada and Tehachapi Mountains

MLRA 22A Major Land Resource Area 22A, Sierra Nevada Mountains, is located predominantly in California and a small section of western Nevada. The area lies completely within the Sierra Nevada Section of the Cascade-Sierra Mountains Province. The Sierra Nevada range has a gentle western slope, and a very abrupt eastern slope. The Sierra Nevada consists of hilly to steep mountains and occasional flatter mountain valleys. Elevation ranges between 1,500 and 9,000 ft throughout most of the range, but peaks often exceed 12,000 ft. The highest point in the continental US occurs in this MLRA (Mount Whitney, 14,494 ft). Most of the Sierra Nevada is dominated by granitic rock of the Mesozoic age, known as the Sierra Nevada Batholith. The northern half is flanked on the west by a metamorphic belt, which consists of highly metamorphosed sedimentary and volcanic rocks. Additionally, glacial activity of the Pleistocene has played a major role in shaping Sierra Nevada features, including cirques, arêtes, and glacial deposits and moraines. Average annual precipitation ranges from 20 to 80 inches in most of the area, with increases along elevational and south-north gradients. Soil temperature regime ranges from mesic, frigid, and cryic. Due to the extreme elevational range found within this MLRA, Land Resource Units (LRUs) were designated to group the MLRA into similar land units. LRU "C" Northern Sierra Subalpine: Elevations are typically between 7,800 and 9,800 feet. The frost free period is between 30 and 90 days, MAAT is between 35 and 44 degrees, MAP is between 45 and 65 inches. Soils are typically cryic, but frigid soils may occur at lower elevations on southern aspects. Forests are dominated by whitebark pine (*Pinus albicaulis*), Sierra lodgepole pine (*Pinus contorta* spp. *murrayana*), mountain hemlock (*Tsuga mertensiana*) and/or California red fir (*Abies magnifica*).

Classification relationships

Forest Alliance = *Tsuga mertensiana* – Mountain hemlock forest; Association = tentatively *Tsuga mertensiana*-*Pinus contorta* spp. *murrayana*-*Pinus monticola*. (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.)

Ecological site concept

This site occurs on deep sandy skeletal soils, over decomposed granite on north facing slopes and cool, moist basins. It typically occurs at elevations between 7800 and 9000 feet, where snow persists late into the season, and the growing season is short. Slopes range from 15 to 70 percent. The vegetation is mixed subalpine forest, with mountain hemlock (*Tsuga mertensiana*), lodgepole pine (*Pinus contorta* var. *murrayana*), red fir (*Abies magnifica*), and western white pine (*Pinus monticola*). Understory cover and composition varies with the degree of moisture available at a given location. Purple mountainheath (*Phyllodoce breweri*) and rose meadowsweet (*Spiraea splendens*) are often abundant, especially in wetter locations.

Associated sites

F022AC001CA	Cryic Sandy Mountain Slopes Occurs on adjacent slopes with shallow to moderately deep, sandy skeletal soils at or near treeline. The vegetation is a whitebark pine (<i>Pinus albicaulis</i>) forest with very little understory
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F022AC003CA	Frigid-Cryic Sandy Slopes Occurs on adjacent lower elevation sandy slopes. The vegetation is a red-fir (<i>Abies magnifica</i>)- western white pine (<i>Pinus monticola</i>) forest with pinemat mananita (<i>Arctostaphylos nevadensis</i>) dominant in openings.
R022AE202CA	Granitic Pocket Occurs on adjacent lower elevation slopes with a high percentage of rock outcrop and shallow, sandy soils that occur in pockets among bedrock ledges. The vegetation is sparse western juniper (<i>Juniperus grandis</i>)-Jeffrey pine (<i>Pinus jeffreyi</i>)-Sierra lodgepole pine (<i>Pinus contorta</i> var. <i>murrayana</i>) with a sedge-forb community in soil pockets and a huckleberry oak (<i>Quercus vaccinifolia</i>) dominated shrub community among talus.
R022AE213CA	Steep Rubbly Slope Occurs on lower elevation very steep, rubbly slopes with deep soils. The vegetation is a dense shrubland dominated by huckleberry oak (<i>Quercus vaccinifolia</i>) and greenleaf manzanita (<i>Arctostaphylos patula</i>).
R022AX101CA	Frigid Anastomosed System Occurs on adjacent very deep, moist, sandy soils formed in alluvium. This site is dominated by aspen (<i>Populus tremuloides</i>) with a diverse herbaceous understory.

Similar sites

F022AC007CA	North-Facing Cryic Loamy Mountain Slopes This site occurs on moderately deep, andic soils, on north facing slopes. The overstory vegetation is similar, but purple mountainheath and rose meadowsweet are not dominant in the understory.
F022AC002CA	Cryic Sandy North Apsect Mountain Slopes This site occurs in more exposed positions at higher elevations near treeline. Mountain hemlock (<i>Tsuga mertensiana</i>) dominates with whitebark pine (<i>Pinus albicaulis</i>), and there is very little understory vegetation.

Table 1. Dominant plant species

Tree	(1) <i>Tsuga mertensiana</i> (2) <i>Pinus contorta</i> var. <i>murrayana</i>
Shrub	(1) <i>Phyllodoce breweri</i> (2) <i>Spiraea splendens</i> var. <i>splendens</i>
Herbaceous	Not specified

Physiographic features

This ecological site is found on mountain slopes at elevations that may from 6,990 to 9,650 feet, but are typically between 7,800 and 9,000 feet. Slopes may range from 5 to 70 percent, but are typically above 15 percent. Aspects are typically north-facing, but may be variable, and runoff class is very low to low.

Table 2. Representative physiographic features

Landforms	(1) Mountain slope
Flooding frequency	None
Ponding frequency	None
Elevation	2,130 – 2,940 m
Slope	10 – 70 %

Climatic features

The average annual precipitation ranges from 39 to 65 inches, mostly in the form of snow in the winter months (November through April). The average annual air temperature ranges from 38 to 43 degrees Fahrenheit. The frost-free (>32F) season is 50 to 125 days, and the freeze-free (>28F) season is 90 to 160 days. There are no representative climate stations for this ecological site.

Maximum and minimum monthly climate data for this ESD were generated using PRISM data (PRISM Climate Group, Oregon State University, <http://prism.oregonstate.edu>, created 4 Feb 2004.) and the ArcGIS ESD extract tool.

Table 3 Representative climatic features

Frost-free period (average)	130 days
Freeze-free period (average)	80 days
Precipitation total (average)	1,320 mm

Influencing water features

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

Soil features

The soils associated with this ecological site are deep to paralithic granitic bedrock, and formed in colluvium and/or till over residuum derived from granodiorite. They are excessively drained with rapid permeability. The soil moisture regime is typic xeric and the soil temperature regime is cryic. Surface rock fragments smaller than 3 inches in diameter are typically not present, and larger fragments average 45 percent. The surface texture is very gravelly loamy coarse sand. Subsurface textures are very gravelly loamy coarse sand, and partially decomposed plant material (Oi horizon). Subsurface rock fragments smaller than 3 inches in diameter range from 31 to 35 percent by volume, and larger fragments range from 15 to 45 percent (for a depth of 0 to 49 inches). The soils correlated to this site include Dagget (Sandy-skeletal, mixed Typic Cryorthents).

This ecological site has been correlated with the following mapunits and soil components in the Tahoe Basin soil survey area (CA693):

Area_sym ; Musym ; MUname ; Compname ; Local_phase ; Comp_pct

CA693 ; 9405 ; Dagget very gravelly loamy coarse sand, moist, 15 to 30 percent slopes, rubbly ; Dagget ; moist ; 80

CA693 ; 9406 ; Dagget very gravelly loamy coarse sand, moist, 30 to 70 percent slopes, rubbly ; Dagget ; moist ; 80

CA693 ; 9407 ; Dagget-Rock outcrop complex, moist, 30 to 70 percent slopes ; Dagget ; moist ; 55

CA693 ; 7502 ; Rock Outcrop-Rockbound complex, 30 to 70 percent slopes ; Dagget ; moist ; 5

CA693 ; 7484 ; Meeks gravelly loamy coarse sand, 5 to 15 percent slopes, extremely bouldery ; Dagget ; moist ; 3

CA693 ; 7485 ; Meeks gravelly loamy coarse sand, 15 to 30 percent slopes, extremely bouldery ; Dagget ; moist ; 3

CA693 ; 7486 ; Meeks gravelly loamy coarse sand, 30 to 70 percent slopes, extremely bouldery ; Dagget ; moist ; 3
 CA693 ; 7523 ; Tallac gravelly coarse sandy loam, 30 to 70 percent slopes, very stony ; Dagget ; moist ; 1

Table 4. Representative soil features

Parent material	(1) Colluvium – granodiorite
Surface texture	(1) Very gravelly loamy coarse sand
Family particle size	(1) Sandy
Drainage class	Excessively drained
Permeability class	Rapid
Soil depth	100 cm
Surface fragment cover <=3"	Not specified
Surface fragment cover >3"	50 %
Available water capacity (0-101.6cm)	4.57 – 6.86 cm
Soil reaction (1:1 water) (0-101.6cm)	5.6 – 6.5
Subsurface fragment volume <=3" (Depth not specified)	30 – 40 %
Subsurface fragment volume >3" (Depth not specified)	20 – 50 %

Ecological dynamics

This site occurs on deep sandy skeletal soils, over decomposed granite on north facing slopes and cool, moist basins. It occurs at high elevations (approximately 7,000 to 9,600 feet), where snow persists late into the season, and the growing season is short.

The vegetation is mixed subalpine forest, with mountain hemlock (*Tsuga mertensiana*), lodgepole pine (*Pinus contorta* var. *murrayana*), red fir (*Abies magnifica*), and western white pine (*Pinus monticola*). Mountain hemlock and lodgepole pine are more strongly dominant in wetter locations, such as depressions, bedrock seeps, or high steep north-facing slopes, while red fir and western white pine become more important in locations with less moisture availability. The understory is also variable with soil moisture availability, but purple mountainheath (*Phyllodoce breweri*) and rose meadowsweet (*Spiraea splendens*) are common, especially in wetter locations. Relative to

other forest types, these forests occupy the smallest geographic extent within the Lake Tahoe Basin (Taylor et al. 2012).

Ecological/Disturbance Factors

Fire and fire suppression, climate fluctuations and climate warming, and pathogen outbreaks are the primary disturbances impacting this ecological site. The high-elevation, poor access landscape that this site occurs in largely escaped the widespread clear-cutting of the Comstock era in the Lake Tahoe Basin (Elliot-Fisk et al. 1996).

The natural fire return interval (FRI) in this forest is relatively long. A Tahoe Basin study estimated an FRI of 55 years for subalpine mountain hemlock – red fir forests (Taylor et al. 2012). Safford (2014) estimated a mean minimum FRI of 100 years and a mean max FRI of 420 years for subalpine forests in California. Studies from other subalpine mountain hemlock systems have estimated an FRI ranging from 45 to over 700 years (Dickman and Cook 1989, Bekker and Taylor 2010, Mallek et al. 2013). Fire ignitions tend to be fewer and fire severity lower in subalpine forests relative to lower elevations due to lower productivity with lower fuel availability, and a shorter fire season due to cooler temperatures and higher relative humidity, and longer and deeper snowpack (Skinner and Chang 1996, Bekker and Taylor 2010, Mallek et al. 2013). These forests experienced a mixed-severity fire regime, with most fires small and of low severity and more rare large, high severity stand-clearing fires (Bekker and Taylor 2010, Mallek et al. 2013). Successional dynamics following stand-clearing fire in these forests are not well studied. In Oregon, lodgepole pine was found to become dominant after stand-clearing fire in mountain hemlock forests, maintaining dominance for up to 200 years (Dickman and Cook 1989). However a southern Cascades study found that composition in red fir-mountain hemlock forests remained fairly constant after fire (Bekker and Taylor 2010). Slightly lower elevation red fir-western white pine forests in the Lake Tahoe Basin that were logged during the Comstock era are currently dominated by lodgepole pine (Taylor 2007), and it is assumed that lodgepole pine, which is an important component of these forests pre-fire, would initially dominate post-fire phases here.

Fire suppression over the last century has impacted contemporary forests, although since fire return intervals are naturally longer in these forests, the impacts are much slower to develop relative to lower elevation forests (Skinner and Chang 1996, Bekker and Taylor 2010, Mallek et al. 2013). The dominant effect of fire suppression is an increase in forest density, without major changes in forest composition as are seen in other forest types (Bekker and Taylor 2010, Mallek et al. 2013, Safford and Van de Water 2014).

Whether observed changes in forest density in the subalpine are due to fire suppression or due to climate warming are difficult to disentangle. Several studies attribute observed patterns of increased forest density in the subalpine more to climate warming over fire suppression (Dolanc et al. 2012, Mallek et al. 2013, Safford and Van de Water 2014). Between 1929 and 2009, stem density of subalpine forests in the Sierra Nevada increased over 30 percent, 63 percent of which comes from small understory trees (Dolanc et al. 2012). Over the same time period, daily minimum temperatures increased by 1.2 degrees Celsius, and precipitation increased (Dolanc et al. 2012). Areas mapped by the U.S. Forest Service as subalpine forest in the 1930s are currently mapped as red fir (Safford and Van de Water 2014), indicating a potential compositional shift in these forests. Mountain hemlock establishment is positively affected by warm wet climatic periods, with historic mountain hemlock forest expansion occurring during these climatic phases (Taylor 1995). Lodgepole pine recruitment is also positively impacted by warm wet periods with low snowpack (Pierce and Taylor 2011). Increases in subalpine forest density, likely due to a warmer climate, are already occurring. Recent California based climate models predict a 9 degree F increase in temperature by 2100, and more conservative models predict a 2 to 4 degree F increase in winter and 4 to 8 degree increase in summer (Safford et al. 2012). Models are more variable for precipitation, but recent models for the Sierra Nevada, predict similar to slightly less precipitation. Most models agree that summers will become drier, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Safford et al. 2012). These scenarios will bring more extreme changes to subalpine forests. Species requiring cool, moist conditions to dominate, such as mountain hemlock, will likely be pushed upslope, while species with wider ecological amplitude, such as red fir and lodgepole pine, may remain dominant in this site. With extreme warming, lower montane species like Jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies magnifica*) will likely move into the elevation zone occupied by this site. How pathogens, both existing and novel, increased fire frequencies with increased tree densities, introduced species, mycorrhizal relationships, and new species interactions will impact dynamics under these warming scenarios is unknown.

Several pathogens may impact the dominant tree species of this ecological site, but none have been observed to initiate community phase shifts or state transitions. A description of these pathogens may be found in the Other information narrative of the Site Interpretations section of this ESD.

The reference state consists of the most successional advanced community phase (numbered 1.1) as well as other community phases that result from natural and human disturbances. Community phase 1.1 is deemed the phase representative of the most successional advanced pre-European plant/animal community including periodic natural surface fires that influenced its composition and production.

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

Additional community tables

Table 5. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 6. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height M	Canopy Cover (%)	Diameter Cm	Basal Area (square M/hectare)
Tree							
Sierra lodgepole pine	PICOM	<i>Pinus contorta var. murrayana</i>	Native	–	1-30	10.2-78.7	–
mountain hemlock	TSME	<i>Tsuga mertensiana</i>	Native	–	9-30	10.2-101.6	–
western white pine	PIMO3	<i>Pinus monticola</i>	Native	–	0-22	10.2-119.4	–
California red fir	ABMA	<i>Abies magnifica</i>	Native	–	0-10	10.2-86.4	–

Table 7. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (m)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
shorthair reedgrass	CABR	<i>Calamagrostis breweri</i>	Native	–	0-2
Parry's rush	JUPA	<i>Juncus parryi</i>	Native	–	0-1
pullup muhly	MUF12	<i>Muhlenbergia filiformis</i>	Native	–	0-0.5
Forb/Herb					
Canada goldenrod	SOCA6	<i>Solidago canadensis</i>	Native	–	0.5-1
mountain pride	PENE3	<i>Penstemon newberryi</i>	Native	–	0-1
Sierra beardtongue	PEHE2	<i>Penstemon heterodoxus</i>	Native	–	0-1
California false hellebore	VECAC2	<i>Veratrum californicum var. californicum</i>	Native	–	0-1
longspur lupine	LUAR6	<i>Lupinus arbustus</i>	Native	–	0-1
sidebells wintergreen	ORSE	<i>Orthilia secunda</i>	Native	–	0-0.5
tundra aster	ORALA3	<i>Oreostemma alpigenum var. andersonii</i>	Native	–	0-0.5
lambstongue ragwort	SEIN2	<i>Senecio integerrimus</i>	Native	–	0-0.5
whiteveined wintergreen	PYPI2	<i>Pyrola picta</i>	Native	–	0-0.5
high mountain cinquefoil	POFL3	<i>Potentilla flabellifolia</i>	Native	–	0-0.5
Shrub/Subshrub					
purple mountainheath	PHBR4	<i>Phyllodoce breweri</i>	Native	–	0-60
rose meadowsweet	SPSPS	<i>Spiraea splendens var. splendens</i>	Native	–	0-30
western moss heather	CAME7	<i>Cassiope mertensiana</i>	Native	–	0-6
dwarf bilberry	VACE	<i>Vaccinium cespitosum</i>	Native	–	0-3
gooseberry currant	RIMO2	<i>Ribes montigenum</i>	Native	–	0-3
sticky currant	RIVI3	<i>Ribes viscosissimum</i>	Native	–	0-3
pinemat manzanita	ARNE	<i>Arctostaphylos nevadensis</i>	Native	–	0-3
Scouler's willow	SASC	<i>Salix scouleriana</i>	Native	–	0-2
Sierra willow	SAOR	<i>Salix orestera</i>	Native	–	0-2
western Labrador tea	LEGL	<i>Ledum glandulosum</i>	Native	–	0-1
Tree					
Sierra lodgepole pine	PICOM	<i>Pinus contorta var. murrayana</i>	Native	–	1-3
mountain hemlock	TSME	<i>Tsuga mertensiana</i>	Native	–	1-3
California red fir	ABMA	<i>Abies magnifica</i>	Native	–	0.5-1

Table 8. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 9. Community 1.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 10. Community 1.4 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Table 11. Community 1.5 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production ()	Foliar Cover (%)
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Animal community

Almost 50 bird species and many mammals use this forest for food, cover, or habitat. Common animals include bears, deer, chipmunks, and squirrels. Dead or dying trees provide nesting sites for cavity-nesting birds, and the fallen branches from these trees provide sites for ground-nesting birds and mammals. Conifer seeds are a food source for squirrels, chipmunks, birds, and mice (Cope 1993, Tesky 1992).

Recreational uses

This area provides beautiful scenery and is used for backpacking, hiking, bike riding, photography, and other activities.

Wood products

The remoteness of this area and the slow growth of trees at this elevation make commercial forestry production impractical. However, the wood of Sierra lodgepole pine, mountain hemlock, California red fir and western white pine is of good quality. Sierra lodgepole pine is suited for common lumber grades, and used for light framing materials, interior paneling, exterior trim, posts, railroad ties, pulp and paper, and has potential for structural particle board. The uniform size of Sierra lodgepole pine makes harvesting efficient (Cope 1993). The wood of California red fir is of high quality and is stronger than other firs. It is used for fuel, coarse lumber, quality veneers, solid framing, plywood, printing paper, and high-quality wrapping paper, and is preferred for pulping (Cope 1993). Western white pine can produce valuable timber and is often used for finish work. It is used to build doors, paneling, dimension stock, matches, and toothpicks. The wood is also excellent for carving (Griffith 1992). The wood of mountain hemlock is moderately strong and light colored. It is most often used for small-dimension lumber and pulp. The wood is also used for railway ties, mine timbers, interior finish, crates, kitchen cabinets, and flooring and ceilings (Tesky 1992).

Other information

Site index documentation: Schumacher (1928), Alexander (1966), Barnes(1962) and Dunning (1942) were used to determine forest site productivity for red fir, Sierra lodgepole pine, mountain hemlock and western white 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. (CMAI values are not available for western white pine, so zeros were used to indicate the lack of data.) 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. Trees appropriate for site index measurement typically occur in stands of community phases 1.3 and 1.4. Site trees are selected according to guidance in reference publications. Please refer to the Tahoe Basin Soil Survey for detailed site index information by soil component. Pathogen information: Several pathogens can affect mountain hemlock, but its patchy distribution in this area makes epidemics rare. These pathogens include laminated root rot (*Phellinus weiri*), heart rots, such as Indian paint fungus (*Echinodontium tinctorum*), several needle diseases, snow mold (*Herpotrichia nigra*), and dwarf-mistletoe (*Arceuthobium tsugense*) (Tesky 1992). Sierra lodgepole pine has been killed by the mountain pine beetle (*Dendroctonus ponderosae*) at lower elevations, but beetle infestations in this mixed subalpine forest seem to be less severe. Lodgepole pine dwarf mistletoe (*Arceuthobium americanum*) is present in some areas. The major pathogens that affect California red fir in this area include: 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 and Knopp 2000). Other diseases also affecting red fir are known as heart rots, which cause the centers of limbs and trunks to decay. Commonly seen heart rots include: yellow cap fungus (*Pholiota limonella*) and Indian paint fungus (*Echinodontium tinctorium*). Common pests affecting red fir are cone maggots (*Earomyia* spp.), several chalcids (*Megastigmus* spp.) and cone moths (*Barbara* spp. and *Eucosma* spp.) (Burns and Honkala 1990). Red fir dwarf mistletoe (*Arceuthobium abietinum* f. sp. *magnificae*) is a parasitic plant common in the survey area. Visible symptoms include witches brooms, top kill, stem cancers, and swellings. The vegetative shoots of the dwarf mistletoe are also often present from spring to fall. Infestation of the red fir dwarf mistletoe can cause reduced growth and vigor, which 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 and the cytospora canker (*Cytospora abietis*) (Burns and Honkala 1990). Fir broom rust (*Melampsorella caryophyllacearum*) causes dense witches brooms with stunted yellow

needles, and can damage tree growth by reducing crown development. Mortality is less common in mature trees than in the younger regeneration trees. 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) Annosus root rot (*Heterobasidion annosum*) can affect large acres of fir forest. It slowly decays the roots, the root collar and the stem butt for many years causing structural weaknesses and making the tree vulnerable to windthrow. Annosus root rot can spread from infected roots to healthy roots as well as aerially by infecting freshly cut stumps or other fresh tree wounds. Painting Borax on the freshly cut stumps restricts the entry of the fungus. In all management activities, it is important to reduce damage to the bark because the rot itself does not often kill red fir directly, but it weakens the tree and makes it easier for bark beetles (*Scolytus* spp), annosus root rot, or dwarf mistletoe to infect the tree (Burns and Honkala 1990). The fir engraver (*Scolytus ventralis*) can cause extensive damage to a red fir forest and outbreaks can cause several acres of trees to die. It can reach epidemic levels when the trees are stressed due to annosus root rot, dwarf mistletoe, drought, or fire damage (Burns and Honkala 1990). The major pathogen affecting western white pine is 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. The leaves on the upper portion eventually turn red and fall (Hagle et al. 2003). Pruning cankers off of infected stems has been shown to be beneficial. Some strains of western white pine have shown resistance to the disease. Other pathogens that can affect western white pine are: white pine needle cast (*Lophodermella arcuata*), pine needle cast (*Lophodermium nitens*), *Bifusella lineari*, butt-rot fungi, red ring rot (*Phellinus pini*), root disease (*Phaeolus schweinitzii*), annosus root rot (*Heterobasidion annosum*), and *Armillaria* root disease (*Armillaria* spp). Insects affecting western white pine include: Mountain pine beetle (*Dendroctonus ponderosae*), emarginate ips (*Ips emarginatus*), and ips beetle (*Ips montanus*) (Taylor and Halpern 1991).

Table 12. 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	21	21	79	79	140	050	50TA	Schumacher, Francis X. 1928. Yield, stand and volume tables for red fir in California. University of California Agricultural Experiment Station Bulletin 456.
mountain hemlock	TSME	55	55	45	45	70	990	100TA	Barnes, George H. 1962. Yield of even-aged stands of western hemlock. USDA, Forest Service. Pacific Northwest Forest and Range Experiment Station Technical Bulletin 1273.
Sierra lodgepole pine	PICOM	53	53	41	41	90	520	100TA	Alexander, Robert R. 1966. Site indexes for Lodgepole pine, with corrections for stand density: instructions for field use. USDA, Forest Service. Rocky Mountain Forest and Range Experiment Station Research Paper RM-24.
western white pine	PIMO3	80	80	0	0	0	605	300TA	Dunning, Duncan. 1942. A site classification for the mixed-conifer selection forest of the Sierra Nevada. USDA, Forest Service. California Forest and Range Experiment Station Research Note 28.

Inventory data references

The following NRCS plots represent community phase 1.1. of this ecological site: rx03046 - Type location rx03054 rx03059 rtg02h39

Type locality

Location 1: El Dorado County, CA	
UTM zone	N
UTM northing	4313145
UTM easting	747419
General legal description	Take Hwy 89 to Eagle falls trailhead to upper Velma Lake. Go down the creek from Upper Velma Lake outlet. The plot is on the north side of the creek.

Other references

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Bekker, M. F. and A. H. Taylor. 2010. Fire disturbance, forest structure, and stand dynamics in montane forests of the southern Cascades, Thousand Lakes Wilderness, California, USA. *Ecoscience* 17:59-72.

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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:
