Ecological site F022AC002CA
Cryic Sandy North Apsect 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.

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): 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 = Pinus albicaulis – Whitebark pine forest; Association = tentatively Pinus albicaulis/Achnatherum californica (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 ecological site occurs in the highest elevations of the northern subalpine LRU, typically between 9,000 and 10,500 feet on north facing mountain slopes. Slopes are typically between 30 and 50 percent. Soils are derived from granitic parent material, and are moderately deep to very deep over paralithic granitic bedrock, with a sandy skeletal particle size class. The site is characterized by mountain hemlock and whitebark pine forests. Northern aspects retain snow later into the summer, and the additional moisture supports mountain hemlock.

Associated sites

F022AC001CA	**Cryic Sandy Mountain Slopes** This ecological site occurs on south facing aspects and higher elevations. Whitebark pine forests are present.
F022AC003CA	**Frigid-Cryic Sandy Slopes** This ecological site occurs at lower elevations and is dominated by California red fir (Abies magnifica)-western white pine (Pinus monticola) forests.
F022AC006CA	**Moderately Deep Cryic Sandy Till** This ecological site occurs on volcanic till, with an open forest of Sierra lodgepole pine (Pinus contorta var. murrayana) and California red fir (Abies magnifica).
F022AC007CA	**North-Facing Cryic Loamy Mountain Slopes** This ecological site occurs volcanic soils on north facing aspects. A mixed subalpine forest is present composed of mountain hemlock, western white pine, lodgepole pine (Pinus contorta var. murrayana), and California red fir.
F022AF004CA	**Frigid, Shallow To Deep, Sandy Mountain Slopes** This ecological site occurs on shallow to moderately deep, frigid soils, on southern aspects, with an open Jeffrey pine forest, and montane shrubs.
F022AX101CA	**Moist Colluvial Headwater System** This ecological site occurs in headwater swales, with quaking aspen (Populus tremuloides) forests dominant.
R022AA200CA	**Alpine Scree** This ecological site occurs in the alpine LRU, on mountain peaks and ridges, an alpine forb community is dominant.
R022AA201CA	**Sandy Shallow Alpine Mountain Slopes** This ecological site occurs at the lower elevations of the alpine LRU. Whitebark pine is reduced to Krummholtz form.
R022AC204CA	**Cryic, Umbric Or Andic Slopes** This ecological site occurs on soils with an umbric horizon or volcanic parent material. Mountain sagebrush (Artemisia tridentata spp. vaseyana) and antelope bitterbrush (Purshia tridentat) are dominant.

Similar sites

F022AB109CA	**Very Steep Stony North Slopes** This ecological site occurs in the southern Sierra Nevada subalpine LRU. Soils are typically finer textured, and the ESD is much more restricted do to drier climate.

F022BI124CA	**Upper Cryic Slopes** This ecological site occurs in the Cascade Mountain MLRA 22B. This site has higher precipitation and is on volcanic soils. A mountain hemlock-whitebark pine woodland is present.
F022AC001CA	**Cryic Sandy Mountain Slopes** This ecological site occurs on southern aspects and higher elevations. Whitebark pine woodlands are present, but lack co-dominance of mountain hemlock.
F022BI104CA	**Cryic Coarse Loamy Colluvial Slopes** This ESD occurs in the southern Cascade MLRA22B region. Higher precipitation and volcanic soils develop a productive mountain hemlock forest. Whitebark pine is typically absent.
F022AC005CA	**Cryic Sheltered, Moist Sandy Mountain Slopes** This ecological site occurs on northern aspects on granitic soils. A mixed subalpine forest is present, dominated by mountain hemlock and Sierra lodgepole pine. Whitebark pine is typically absent.

Table 1. Dominant plant species

Tree	(1) *Tsuga mertensiana* (2) *Pinus albicaulis*
Shrub	Not specified
Herbaceous	(1) *Eriogonum ovalifolium* (2) *Hieracium horridum*

Physiographic features

This site is on moderate to steeply sloping mountain sides at elevations ranging from 8500 to 12,000 feet, but are typically between 9,000 and 10,500 feet. This site is generally orientated on north to east-facing slopes which may range from 15 to 50 percent but are typically between 30 and 50 percent.

Table 2. Representative physiographic features

Landforms	(1) Mountain slope (2) Mountain
Flooding frequency	None
Ponding frequency	None
Aspect	N, NE, NW

Climatic features

The average annual precipitation ranges from 35 to 55 inches, and falls mostly in the form of snow from November to April. The mean annual air temperature ranges from 34 to 37 degrees Fahrenheit. The frost-free (>32F) season is 25 to 45 days, and the freeze-free (>28F) season is 35 to 60 days.

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)	35 days
Freeze-free period (average)	47 days
Precipitation total (average)	45 in

Influencing water features

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

Soil features

The soils associated with this ecological site are moderately deep to very deep, and formed in colluvium and residuum derived from granitic rock. They are somewhat excessively drained with rapid permeability. The soil moisture regime is xeric and the soil temperature regime is cryic. Surface rock fragments smaller than 3 inches in diameter range 15 to 70 percent cover, and larger fragments range from 10 to 22 percent. Surface textures are very cobbly loamy coarse sand and gravelly loamy sand. Subsurface textures are extremely and very stony loamy coarse sand. Subsurface rock fragments smaller than 3 inches in diameter range from 20 to 70 percent by volume and larger fragments range from 5 to 32 percent (for a depth of 0 to 60 inches). The Whittell (Sandy-skeletal, mixed Typic Cryorthents) and Klausepeak (Sandy-skeletal, mixed Xeric Humicryepts) soils are correlated to this ecological site. The Whittell soils have moderately cemented granitic bedrock at 20 to 40 inches.

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

9421;Jobsis-Whittell-Rock outcrop complex, cool, 8 to 30 percent slopes;Klauspeak;;2
Sofgran-Klauspeak-Temo association, 15 to 50 percent slopes;Klauspeak;;30
9461;Whittell-Jobsis-Rock outcrop complex, cool, 30 to 75 percent slopes;Klauspeak;;2
9402;Dagget very gravelly loamy coarse sand, 30 to 50 percent slopes, extremely bouldery;Whittell;;3

Table 4. Representative soil features

Parent material	(1) Colluvium–granodiorite
Surface texture	(1) Very cobbly loamy coarse sand (2) Very stony coarse sand
Family particle size	(1) Sandy
Drainage class	Somewhat excessively drained
Permeability class	Rapid
Soil depth	20–80 in
Surface fragment cover <=3"	45–90%
Surface fragment cover >3"	2–50%
Available water capacity (0-40in)	0.9–2.8 in
Electrical conductivity (0-40in)	0–4 mmhos/cm
Soil reaction (1:1 water) (0-40in)	5.1–6.5
Subsurface fragment volume <=3" (Depth not specified)	20–50%
Subsurface fragment volume >3" (Depth not specified)	10–30%

Ecological dynamics

Abiotic Features:

This ecological site occurs in the highest elevations of the northern subalpine LRU, typically between 9,000 and 10,000 feet on north facing mountain slopes. Soils are derived from granitic parent material, and are moderately deep over paralithic granitic bedrock, with a sandy skeletal particle size class. North-facing aspects hold snow for longer into the summer, providing additional moisture that allows mountain hemlock to be co-dominant or dominant over whitebark pine.

Ecological Features:

The high elevations in which this site occurs are buried with deep snow from November to June and remain cool for most of the year. Several physiological adaptations allow mountain hemlock and white bark pine to survive in this cold environment. Both species have maximum photosynthetic rates at colder temperatures than lower elevation trees, and close stomata to reduce water loss during dry or cold periods (Smith and Hinckley 1995). The tips of mountain hemlock branches are very flexible, an attribute that reduces snow build-up and stem breakage. Snow burial can be helpful in protecting trees from strong winter winds, desiccation from warm winter winds and sunny winter days, extreme cold, and repeated freezing and thawing (Arno and Hammerly 1984). Snow burial can, however, be detrimental as well. For example, portions of trees exposed above the snow can die back, leaving short multi-stemmed trees. Snow creep can create J shaped tree trunks, and avalanches can destroy swaths of forest.

Timberline trees are able to withstand extremely cold winter conditions when they are dormant, but need at least a 2 to 3-month frost free growing period in the summer. Leaves, shoots, cones, and new seedlings develop during this short growing season, typically from mid-June through August. As elevations increase, temperatures drop and the growing season is shortened. Growing season length is one of the limiting factors to determine treeline. Another is wind. Wind induced treelines can be caused by drought conditions, due to increased evapotranspiration (Tomback et al. 2001).

Whitebark pine is a long-lived timberline tree species that grows 40 to 60 feet tall in favorable conditions. The cones are indehiscent, meaning they do not open at maturity. Caching of whitebark pine seeds by Clark’s nutcracker is the primary mode of seed dispersal. Seeds are often cached in open areas that are suitable for young seedlings. If all seeds are not consumed, they give rise to dense clusters of genetically similar whitebark pine. These clusters appear to be one tree with many stems, but are more often individual trees (Burns et al. 1990, Tomback et al. 2001a). In the absence of disturbance, ongoing recruitment from seed-caching occurs, leading to an increase in stand density over time.

White bark pine germination and seedling survival is best in canopy openings, such as those created by small fires. This is especially important in areas where whitebark pine develops dense canopies or can be replaced by shade tolerant conifers, as in the northern Cascades and the Rocky Mountains (Arno and Hoff 1990, Tomback et al. 2001, Howard 2002) and the cool, north-facing slopes of this ecological site. The slow growing, shade-tolerant mountain hemlock will gradually gain dominance over whitebark pine in the absence of fire or other disturbance in this ecological site.

Disturbance features:

Fire and avalanche are the primary natural drivers for succession in this site. Fire ignition is frequent on these exposed ridges and mountain peaks, but there is minimal and discontinuous fuel to carry large or hot fires. Small fires may play a minor role in maintaining openings that favor the germination and survival of young whitebark pine seedlings (Burns et al. 1990, Tomback et al. 2001, Howard 2002). Avalanche is common among the alpine peaks and ridges, and can remove swaths of vegetation in avalanche prone chutes or below wind formed cornices.

Natural fire return intervals for whitebark pine and mountain hemlock forests in the Sierra Nevada are poorly documented. Fire occurrence for mountain hemlock in the Pacific Northwest may range from 400 to 800 years, and is typically stand replacing (Tesky 1992). However, the Pacific Northwest is much wetter and has a different stand structure than mountain hemlock in the Sierra Nevada. The mean fire return intervals for whitebark pine forest across the US range from 29 to 300 years, while moderate severity fires range from 25 to 75 years, and stand replacing fires occur at greater than 140 year intervals (Fryer 2002). These whitebark pine studies are primarily from areas where whitebark pine forms continuous forests, rather than the small, open stands typically found in the Sierra Nevada.

Whitebark pine forests are threatened by the non-native Cronartium ribicola, the cause of white pine blister rust (WPBR) and the native mountain pine beetle (Dendroctonus ponderosae) (Cox 2000, Tomback et al. 2001b, Howard 2002). Severe epidemics of WPBR in combination with MPB outbreaks have killed large areas of forest in the Rocky Mountains, but the whitebark pine forests in the Sierra Nevada have not suffered as high mortality. There is a complex interaction between MPB outbreaks, WPBR infection, and climate. Mountain pine beetles prefer larger diameter trees (> 6 inch diameter at breast height), as these are necessary to complete their life cycle, and attack at the warmer, lower elevation zone of whitebark pine. Mountain pine beetles preferentially attack trees infected by WPBR. White pine blister rust will infest all whitebark pines, regardless of age or elevation (Cluck 2014).

Mountain pine beetles are a native species in North American forests, but warmer temperatures have shifted the thermal zone for mountain pine beetles upslope, subjecting higher elevations of whitebark pine to beetle attacks (Craig 2010, Keane et al. 2012, Keane and al 2013). Severe mountain pine beetle epidemics cause high mortality of overstory trees, while understory suppressed trees may be released (Meyer and Safford 2014). A flush of regeneration may occur due to the reduction in the overstory canopy. However, the decline in seed production due to the loss of large overstory trees will leave fewer seeds available for regeneration, threatening stand sustainability.

The non-native WPBR was introduced into North America near Vancouver, British Columbia in approximately 1910, and has been slowly spreading across the western United States and Canada (Maloney 2011). It currently occurs throughout the Cascades, and north and central Sierra Nevada. So far, it has not been detected on whitebark pine in the southern extent of the Sierra Nevada, but has been found on a whitebark pine in Yosemite National Park and in a high Sierra location on the western slope of the Sierra National Forest (Maloney 2011). A survey was conducted in 2009 to determine WPBR presence and affect on whitebark pine survivorship in the Lake Tahoe Basin. Mean incidence of WPBR among whitebark pine populations was 35 percent, with a range of 1 to 65 percent (Maloney et al. 2012).

In order for WPBR to infect whitebark pine several synchronous phenological and environmental factors need to occur. For infection to occur in five-needled white pines, relative humidity has to be greater than 90 percent, temperatures have to be between 35.6 and 64.4 degrees F (2 to 18 degrees C), and stomates need to be open to allow WPBR entry (Maloney 2011). The basidiospores, which infect whitebark pine, are released in fall from the alternate host currants (Ribes sp.), or less commonly, lousewort or Indian paintbrush (Pedicularis or Castilleja sp.). These spores do not travel far or last long in the environment, and years with late summer or early fall precipitation are most likely when infection will occur. Whitebark pine may have early onset winter dormancy, so stomates are closed at the time WPBR basidiospores are released (Maloney 2011). The onset of winter dormancy is dependent upon the length of the growing season (temperature), precipitation and soil available water capacity (AWC).

There appears to be a relationship between soils with higher AWC and higher infection rates or intensity of stem girdling (Maloney et al. 2012). Higher soil moisture could increase WPBR mycelium growth rates and increase basidiospore production, while also allowing for whitebark pine stomates to remain open longer in the season, increasing the probability of infection (Maloney et al. 2012). This ecological site occurs on shallow to moderately deep sandy-skeletal soils, with lower AWC than the corresponding volcanic ecological site (R022AC200CA), and is likely less susceptible to WPBR infestation. A 2009 inventory of WPBR showed that the whitebark stands occurring on granitic soils had infestation rates ranging from 1 to 56% (22% average), while stands on volcanic soils ranged from 34 to 65%(with an average of 49%(Maloney et al. 2012).

The main impact of WPBR on whitebark pine is reduction in stand cone production due to die-back of cone bearing branches from cankers girdling the branches. Mortality rates in older trees are low, and may take decades to occur. Younger trees may be killed quickly if main stem girdling causes disruption of water flow (Maloney et al. 2012). A few studies have been conducted on genetic resistance to WPBR, and results range from no resistance (Maloney, personal communication), to 26 to 47 percent in the Rocky Mountains and the Pacific Northwest (Keane et al. 2012).

Reduced seed production affects the presence and abundance of Clark's nutcracker, and thus the number and distribution of seed caches (Tomback and Resler 2007, Keane et al. 2012). This can lead to recruitment below the threshold required to sustain populations (McKinney et al. 2009).

Mountain hemlock is not susceptible to WPBR or MPB, but trees over 80 years old are very susceptible to laminated root rot (Phellinus weirii). Laminated root rot can rapidly spread by root contact and kill acres of forests (Tesky 1992).

Reestablishment of mountain hemlock after a fire or other disturbance is often slow, and in some areas growth never regains its tree-like stature (Arno and Hammerly 1984). Mountain hemlock has relatively thick bark, but typically has dense, low branches that make the trees susceptible to canopy fires. Mountain hemlock has higher cone production, seed germination and seedling survival rates during years of higher precipitation. Mountain hemlock can also reproduce by layering. Mountain hemlock seeds are wind dispersed and germinate on the snow or soil surface. Seedlings do best with partial shade from whitebark pine or older mountain hemlocks.

Predictions about climate change due to global warming suggest that the whitebark pine communities in the Sierra Nevada Mountains may be threatened by rising temperatures and precipitation changes. Recent California based climate models predict a 9 degree F increase in temperature by 2100, and broader 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 local 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). Presently a severe drought is occurring in the Sierra Nevada, with 10 to 30 percent of average precipitation and very little snow accumulation. Whether this is climate driven, and thus will become more of the future normal, remains to be seen.

High elevation areas with suitable soils and landforms for the upward migration of mountain hemlock and whitebark pine will be important for the sustainability of this community. However, in this region of the central Sierra Nevada, whitebark pine already occurs at the uppermost elevations of the highest mountains in the area, so has little room to move upslope. The southern Sierra Nevada, with its higher mountain peaks, may prove to be an important refugium for this species. Mountain hemlock has more room to migrate as it occurs further to the north, and at lower elevations than whitebark pine. The southern Sierra Nevada is typically too dry for extensive mountain hemlock forest.

The historic temperature range for this ecological site is between 34 to 37 degrees F. With moderate warming on these northern aspects California red fir (*Abies magnifica*) is the most likely conifer to move into the area occupied by this ecological site.

The reference state consists of the most successionally 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 successionally advanced pre-European plant/animal community including periodic natural surface fires that influenced its composition and production. This phase is determined from the oldest modern day remnant forests and/or historic literature.

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

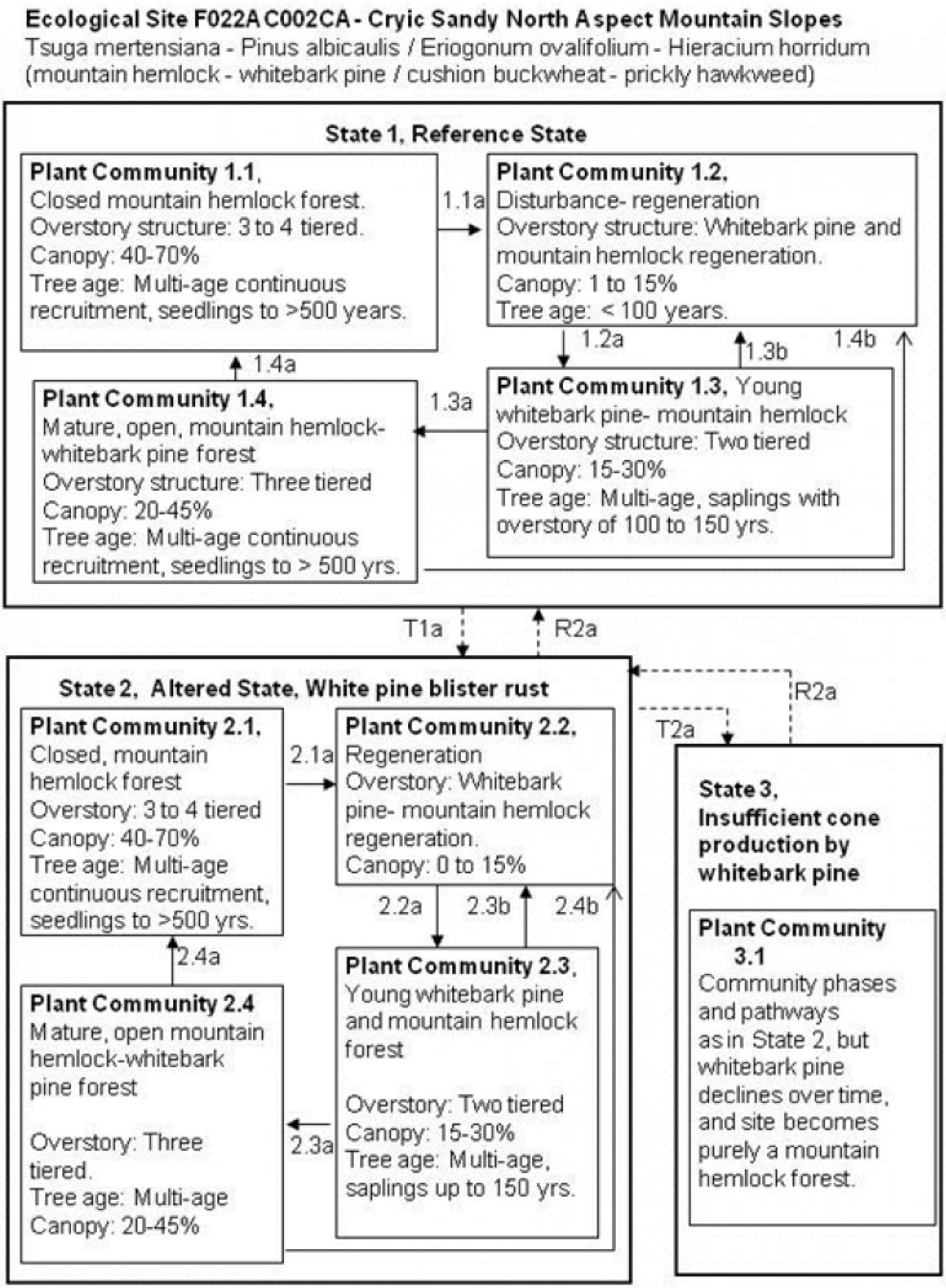

Figure 6. F022AC002CA STM

State 1
Reference

This state represents the reference conditions for this ecological site. A portion of this ecological site exists in this state in stands that do not show symptoms of WPBR.

Community 1.1
Closed mountain hemlock forest

Figure 7. Closed mountain hemlock forest

This community develops with prolonged time since fire (>500 years). The shade-tolerant mountain hemlock continues to establish in the understory, and slowly the stand increases in cover and density. Whitebark pine is overtopped and shaded out by mountain hemlock, and without canopy openings from disturbance, the shade intolerant seedlings will not have significant regeneration. Clark's nutcrackers also prefer to cache seeds in open areas, so the seed supply for whitebark pine is limited under this dense canopy.

Forest overstory. The forest overstory height ranges from 55 to 70 feet, and is dominated by mountain hemlock with a minimal component of tall whitebark pine. A mid layer with canopy heights typically between 20 and 35 feet is a mix of mountain hemlock and whitebark pine. Tree ages in the mid canopy range from 80 to 140 (8 and 12 inch dbh respectively) years for whitebark pine and 100 to 106 years (8 to 10 inch dbh respectively) for mountain hemlock. Sierra lodgepole pine (Pinus contorta var. murrayana) and western white pine (Pinus monticola) may be present in small amounts.

Forest understory. The understory is dominated by young mountain hemlock saplings, with an extremely sparse herbaceous understory.

Table 5. Ground cover

Tree foliar cover	40-70%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	5-35%
Surface fragments >0.25" and <=3"	5-30%
Surface fragments >3"	30-85%
Bedrock	0-1%
Water	0%
Bare ground	1-15%

Table 6. Soil surface cover

Tree basal cover	3-10%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	5-35%
Surface fragments >0.25" and <=3"	5-30%
Surface fragments >3"	30-85%
Bedrock	0-1%
Water	0%
Bare ground	1-15%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0-1%	0%	0%	0-1%
>0.5 <= 1	0-1%	–	–	–
>1 <= 2	0-1%	–	–	–
>2 <= 4.5	0-1%	–	–	–
>4.5 <= 13	1-10%	–	–	–
>13 <= 40	10-30%	–	–	–
>40 <= 80	30-45%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 1.2
Disturbance- regeneration

This community develops after moderate to high severity canopy fires. Avalanches may also remove swaths of trees. Whitebark pine is dependent upon Clark's nutcracker for seed dispersal. Clark's nutcracker prefers to cache seeds in open or disturbed areas, and those that are not recovered germinate and create young tree clusters. Seed predation in normal years may be up to 97 percent, leaving few seeds for germination. Germination and seedling establishment after fire may take several years because of high seed predation rates and a short dormancy period in some seeds. Years with higher summer precipitation may have higher cone yields. The cones take two years to develop. After favorable cone production cycles, there will be more seeds left by predators for germination (Fryer 2002). Growth of young seedlings is slow. In a typical stand, whitebark pine reaches cone maturity at 60 to 100 years (Fryer 2002). Mountain hemlock has winged, wind-dispersed seeds. Mountain hemlock seedlings develop best in partial shade, are very slow growing, and may take decades to establish after a fire. They have higher recruitment and survivability after whitebark pine has established.

Community 1.3
Young whitebark pine- mountain hemlock forest

This phase is comprised of young multiple and single-stem whitebark pine trees that range in age from 80 to 150 years old. Mountain hemlock increases in cover, with more favorable recruitment under the partial shade provided by whitebark pine. Total canopy cover ranges from 15 to 30 percent.

Community 1.4
Mature, open mountain hemlock-whitebark pine forest

Figure 8. Mature, open mountain hemlock- whitebark pine

This phase is dominated by a canopy of mountain hemlock co-dominated by taller primarily single-stem whitebark pines. Canopy cover ranges 20 to 45 percent. Overstory canopy height ranges from 35 to 55 feet with ages of 150 to 500 years old. Western white pine (*Pinus monticola*) and California red fir may occur in limited amounts. The understory is dominated by litter, gravel, and rock with low cover of graminoid, herbaceous and subshrub species.

Forest overstory. Canopy cover ranges 20 to 45 percent, and can be dominated by mountain hemlock or whitebark pine. This phase is typically only one tier over the regeneration layer and seedlings. Overstory canopy height ranges from 35 to 55 feet with ages of 150 to 300 years old. Western white pine, Sierra lodgepole pine, and California red fir may occur in limited amounts.

Forest understory. The understory is relatively sparse. There is 0 to 5 cover of California red fir, whitebark pine, western white pine, mountain hemlock seedlings and saplings. Shrub cover ranges from 0 to 5 percent and is composed of pinemat manzanita (Arctostaphylos nevadensis), oceanspray (Holodiscus discolor), and wax currant (Ribes cereum). Cover of forbs ranges from 0 to 3 percent, including pioneer rockcress (Arabis platysperma), Lake Tahoe draba (Draba asterophora var. asterophora), marumleaf buckwheat (Eriogonum marifolium), cushion buckwheat (Eriogonum ovalifolium), prickly hawkweed (Hieracium horridum), Pacific hulsea (Hulsea algida), mountain pride (Penstemon newberryi), and spreading phlox (Phlox diffusa).

Table 8. Ground cover

Tree foliar cover	20-45%
Shrub/vine/liana foliar cover	0-5%
Grass/grasslike foliar cover	0-1%
Forb foliar cover	0-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	2-20%
Surface fragments >0.25" and <=3"	25-70%
Surface fragments >3"	1-40%
Bedrock	0-1%
Water	0%
Bare ground	1-15%

Table 9. Soil surface cover

Tree basal cover	1-5%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	2-20%
Surface fragments >0.25" and <=3"	25-70%
Surface fragments >3"	1-40%
Bedrock	0-1%
Water	0%
Bare ground	1-15%

Table 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0-1%	–	0-1%	0-3%
>0.5 <= 1	0-1%	0-5%	–	–
>1 <= 2	0-1%	0-1%	–	–
>2 <= 4.5	0-1%	–	–	–
>4.5 <= 13	0-5%	–	–	–
>13 <= 40	3-20%	–	–	–
>40 <= 80	5-30%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Pathway 1.1a
Community 1.1 to 1.2

Fire, avalanche, or pathogens create canopy openings for stand regeneration.

Pathway 1.2a
Community 1.2 to 1.3

Time, with growth and continued regeneration of whitebark pine and mountain hemlock.

Pathway 1.3b
Community 1.3 to 1.2

Disturbances such as fire, avalanche, pathogens, or insects create canopy openings for stand regeneration.

Pathway 1.3a
Community 1.3 to 1.4

Time, with growth and continued regeneration of whitebark pine and mountain hemlock.

Pathway 1.4a
Community 1.4 to 1.2

Time, growth and continued establishment of mountain hemlock.

Pathway 1.4b
Community 1.4 to 1.2

Fire, avalanche, or pathogens create canopy openings for stand regeneration.

State 2
Altered State, White Pine Blister Rust

This state has developed with the introduction of the non-native white pine blister rust. The majority of this ecological site exists in this state, but percent infection in the stand is relatively low (1-19 percent), and degree of stem girdling is low (Maloney et al. 2012).

Community 2.1
Closed mountain hemlock forest

This community phase is similar as described in 1.1. Mountain hemlock is dominant with several canopy layers. Whitebark pine is shaded out by the overstory. Depending upon the severity of the WPBR in the stand, there may be low mortality or stem dieback of whitebark pine, further shifting dominance to mountain hemlock.

Community 2.2
Regeneration- Disturbance

Regeneration occurs in canopy gaps, from seeds germinating in Clark's nutcracker caches. Overall regeneration is lower due to reduced cone production and a higher percentage of seed consumption by Clark’s nutcracker, and potential infestation and mortality of young seedlings from WPBR infection.

Community 2.3
Young whitebark pine- mountain hemlock forest

This phase is comprised of healthy young multiple and single-stem whitebark pine trees that range in age from 80 to 150 years old. There is also a percentage of WPBR infected trees, and some mortality. Canopy cover ranges from 10 to 30 percent.

Community 2.4
Mature, open mountain hemlock- whitebark pine forest

This community is similar to community 1.4, with an open forest of whitebark pine and mountain hemlock. Whitebark pine has low to moderate infection rates from white pine blister rust. There may be death of infected younger trees, and dieback of infected branches on larger trees.

Pathway 2.1a
Community 2.1 to 2.2

Fire, avalanche or pathogens create canopy openings for stand regeneration.

Pathway 2.2a
Community 2.2 to 2.3

Time and growth of healthy whitebark pine, and continued establishment and slow growth of mountain hemlock.

Pathway 2.3b
Community 2.3 to 2.2

Fire, avalanche, or pathogens create canopy gaps and initiate stand regeneration.

Pathway 2.3a
Community 2.3 to 2.4

Time and growth of healthy whitebark pine and mountain hemlock.

Pathway 2.1a
Community 2.4 to 2.1

Time, growth and continued establishment of mountain hemlock in the understory.

Pathway 2.1b
Community 2.4 to 2.2

Fire, avalanche or pathogens create canopy openings that initiate stand regeneration.

State 3
Insufficient Cone Production

This state occurs when there is insufficient regeneration of whitebark pine due to WPBR infection to maintain stand viability.

Community 3.1
Mountain hemlock forest

This state has not occurred in this ecological site, but it possibly crossed into this state on nearby volcanic soils (R022AC200CA). If cone production continues to decline, and disease resistance is not found, whitebark pine will slowly decline over hundreds of years. In the absence of whitebark pine, this site would become a mountain hemlock forest. The absence of whitebark pine as a "nurse" tree for mountain hemlock after disturbance may delay the re-establishment of mountain hemlock.

Transition T1a
State 1 to 2

This transition is triggered by infection of whitebark pine by Cronartium ribicola, cause of white pine blister rust (WPBR), within this ecological site. WPBR affects the crown and cone producing limbs of mature trees, reducing cone production, and can kill younger trees within a year. The decrease in cone production and high mortality of young trees threatens the regenerative success of this species (Maloney et al. 2012). Repeat waves of infection by WPBR under favorable climatic conditions can worsen the situation. Reduced seed production affects the presence and abundance of Clark’s nutcracker, and thus the number and distribution of seed caches (Tomback and Resler 2007, Keane et al. 2012). This can lead to recruitment below the threshold required to sustain populations (McKinney et al. 2009).

Restoration pathway R2a
State 2 to 1

Restoration practices that have been experimented with include spraying pesticides for mountain pine beetle, and planting of hopeful, disease resistant whitebark pine.

Transition T2a
State 2 to 3

Whitebark pine is dependent upon Clark’s nutcracker for seed dispersal. Clark’s nutcrackers cache seeds for later retrieval. Those caches that are not recovered, germinate in small clusters. WPBR, MPB or the combination of the two, can drastically reduce cone production. This transition occurs when cone production is less than 1000 cones/ Ha and basal area is < .5 m2/ acre. Below this threshold there may be insufficient seeds for dispersal by Clark’s nutcracker (McKinney et al. 2009).

Restoration pathway R3a
State 3 to 2

Restoration practices that have been experimented with include aerial spraying pesticides for mountain pine beetle, out-planting of genetically diverse whitebark pine seedlings, and potential WPBR resistant whitebark pine seedlings.

Additional community tables

Table 11. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
mountain hemlock	TSME	*Tsuga mertensiana*	Native	5–60	30–45	15–25	–
mountain hemlock	TSME	*Tsuga mertensiana*	Native	1–35	10–15	3–15	–
whitebark pine	PIAL	*Pinus albicaulis*	Native	5–35	5–15	3–10	–
whitebark pine	PIAL	*Pinus albicaulis*	Native	15–55	0–2	10–20	–
western white pine	PIMO3	*Pinus monticola*	Native	15–35	0–1	3–10	–
Sierra lodgepole pine	PICOM	*Pinus contorta var. murrayana*	Native	35–55	0–1	10–20	–

Table 12. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Forb/Herb					
Lake Tahoe draba	DRASA2	*Draba asterophora var. asterophora*	Native	–	0–1
Tree					
mountain hemlock	TSME	*Tsuga mertensiana*	Native	0–13	2–10
whitebark pine	PIAL	*Pinus albicaulis*	Native	0–13	0–1

Table 13. Community 1.4 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)

Table 14. Community 1.4 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
mountain hemlock	TSME	*Tsuga mertensiana*	Native	2–60	8–25	15–25	–
whitebark pine	PIAL	*Pinus albicaulis*	Native	35–60	1–5	10–20	–
whitebark pine	PIAL	*Pinus albicaulis*	Native	3–35	1–5	3–10	–
mountain hemlock	TSME	*Tsuga mertensiana*	Native	0–35	1–3	3–15	–
western white pine	PIMO3	*Pinus monticola*	Native	15–35	0–2	3–15	–
Sierra lodgepole pine	PICOM	*Pinus contorta var. murrayana*	Native	15–45	0–1	3–15	–
California red fir	ABMA	*Abies magnifica*	Native	5–55	0–1	15–30	–

Table 15. Community 1.4 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
needlegrass	ACHNA	*Achnatherum*	Native	–	0–1
Forb/Herb					
pioneer rockcress	ARPL	*Arabis platysperma*	Native	–	0–1
Lake Tahoe draba	DRASA2	*Draba asterophora var. asterophora*	Native	–	0–1
spreading phlox	PHDI3	*Phlox diffusa*	Native	–	0–1
mountain pride	PENE3	*Penstemon newberryi*	Native	–	0–1
prickly hawkweed	HIHO	*Hieracium horridum*	Native	–	0–1
cushion buckwheat	EROV	*Eriogonum ovalifolium*	Native	–	0–1
Pacific hulsea	HUAL	*Hulsea algida*	Native	–	0–1
marumleaf buckwheat	ERMA4	*Eriogonum marifolium*	Native	–	0–1
Shrub/Subshrub					
pinemat manzanita	ARNE	*Arctostaphylos nevadensis*	Native	–	0–5
oceanspray	HODI	*Holodiscus discolor*	Native	–	0–1
wax currant	RICE	*Ribes cereum*	Native	–	0–1
Tree					
mountain hemlock	TSME	*Tsuga mertensiana*	Native	0–13	0–2
whitebark pine	PIAL	*Pinus albicaulis*	Native	1–13	0–1
California red fir	ABMA	*Abies magnifica*	Native	0–13	0–1
western white pine	PIMO3	*Pinus monticola*	Native	0–13	0–1

Animal community

Clark’s Nutcracker is the primary forager and seed disperser for whitebark pine seeds. Squirrels and other small mammals also cache seeds, to a lesser degree. Bears have been reported to raid the squirrel middens for the whitebark seeds (Howard 2002). The whitebark seeds provide valuable nutrition, and are an important food source for bears, birds, and rodents. The trees also provide cover for and nesting cavities for birds and other wildlife.

Hydrological functions

The soil associated with this site is in hydrologic group C. These soils have a slow infiltration rate when thoroughly wet as well as a slow rate of water transmission. These soils tend to have a layer that impedes downward movement of water. At this site it is bedrock that tends to obstruct the water.

Recreational uses

Hiking is the main recreation in this area, with some areas being suitable for camping. Due to the highly erodible sandy soil, trails should be constructed carefully.

Wood products

This has very low productivity and is not suited for timber or firewood production.

Other information

Re-vegetation/Restoration of disturbed areas:

The following restoration procedures are outlined in the U. S. Forest Service Fire Effects Information System

(Howard 2002):

1. Assess the local extent, successional status, and vigor of whitebark pine to determine if cone crops will dwindle in the future. (Arno 1986).

2. Inventory stands to document tree age, stand structure, cone production potential, and projected time of successional replacement (Arno 1986, 1993, 1997).

3. Apply and evaluate management-ignited and wild-land for resource benefit fires designed to kill late-successional species and favor whitebark pine.

4. Conduct seed trials with white pine blister rust-resistant stock in areas where natural whitebark pine seed sources have disappeared (Arno 1986).

Inventory data references

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

Community phase 1.1
Ra02h25- Type location
Ra03083
Rx02h50

Community phase 1.4
Rtg02h51
rx03027
Sm03h105

Type locality

Location 1: El Dorado County, CA	
UTM zone	N
UTM northing	4296005
UTM easting	242574
General legal description	The site location is about .25 miles northeast of Waterhouse Peak, in the southern region of Lake Tahoe Basin.

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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):**

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

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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):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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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:**

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17. **Perennial plant reproductive capability:**
