Forest Health Protection
Pacific Southwest Region

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To: District Ranger, Truckee Ranger District, Tahoe National Forest

Subject: Evaluation of the Alpine Meadows Ski Area
(FHP Report NE06-07)

At the request of Jerry Kent, Forester, for the Truckee Ranger District, Danny Cluck, Forest Health Protection (FHP) Entomologist, and Bill Woodruff, FHP Plant Pathologist, conducted a field evaluation of the Alpine Meadows Ski Area on July 6, 2006. The objective of the visit was to evaluate the current forest health conditions, investigate the cause of western white pine (*Pinus monticola*) mortality and to provide recommendations as appropriate. These recommendations will assist with the development of a management plan for this high use recreation area. Jerry Kent accompanied us to the field.

Background

The Alpine Meadows Ski Area is located on the Tahoe National Forest, approximately 10 miles south of Truckee, CA, at an elevation of 7000-8000 feet. Precipitation for the site averages 46-52 inches per year. The forested area is generally a Sierra mixed conifer type with the following species present by order of abundance; red fir (*Abies magnifica*), western white pine (*Pinus monticola*), white fir (*Abies concolor*), lodgepole pine (*Pinus contorta var. murrayana*), Jeffrey pine (*Pinus jeffreyi*) and mountain hemlock (*Tsuga mertensiana*). Some true fir regeneration is occurring but western white pine is deficient within the understory. Approximately 20 to 30 hazard trees, typically bark beetle killed, large diameter western white pine and red fir, are removed each year from areas near ski lifts, buildings, and water lines. The management objectives for this ski area are to maintain healthy trees over the long term, protect regeneration from skiers and snowboarders, and reduce the number of hazard trees.

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Observations

All forested areas appear to be at or above normal stocking levels and are showing many symptoms of decline such as dead tops and limbs and bole decay. There is also an elevated level of tree mortality caused by a combination of bark beetles and pathogens, especially in western white pine and red fir. This mortality combined with high stand density is resulting in heavy fuel loads within the stands.

Mortality is occurring in many large diameter western white pine due to a combination of extensive heartwood decay, white pine blister rust (*Cronartium ribicola*) and dwarf mistletoe infections, most likely mountain hemlock dwarf mistletoe (*Arceuthobium tsugense subsp. Mertensianae*), which infects western white pine associated with mountain hemlock in the Cascade and Sierra Nevada Ranges, and mountain pine beetle (*Dendroctonus ponderosae*) attacks (Figures 1 and 2). Dwarf mistletoe infections in the western white pine do not appear to be widespread and were observed less frequently than white pine blister rust infections. Many younger western white pines are infected with blister rust and have dead and dying tops and limbs. Western white pine is also not regenerating due to several factors such as shading and competition from red fir and the build up of duff and litter on the forest floor. All of these factors can be attributed to the lack of fire over the last 100+ years in many of these stands.

Figure 1: Top-killed western white pine infected with white pine blister rust

Figure 2: Extensive heartwood decay in large western white pine killed by mountain pine beetle.

Red fir is the most abundant tree species in the area and is showing signs of decadence. Many larger diameter trees have significant heart rot, annosus root disease (*Heterobasidion annosum*), dwarf mistletoe (*Arceuthobium abietinum* f.sp. *magnificae*), cytospora canker (*Cytospora abietis*), and fir rust (*Melampsorella caryophyllacearum*). Fir engraver beetle

(*Scolytus ventralis*) is attacking many of these trees causing top kill and whole tree mortality (Figures 3 and 4).

Figure 3: Dead and dying red fir near ski lift.

Figure 4: Red fir limb infected with dwarf mistletoe.

Mountain hemlock, which is a very minor component of the forested area, is showing symptoms of decline such as thinning crowns and branch flagging. Although specific causes were not observed, these conditions are likely due to dwarf mistletoe and/or annosus root disease infections.

Very little mortality is occurring in white fir and Jeffrey pine within the ski area although together they make up a small component of the trees. Lodgepole pine mortality caused by mountain pine beetle is very pronounced in the drainage below the ski resort and a short distance away along the Truckee River.

Discussion and Recommendations

The forested stands in the Alpine Meadows area are typical for eastern Sierra Nevada mixed conifer stands that have had fire excluded for 100+ years; high accumulations of fuels, dense understories made up of shade tolerant species, such as red and white fir, mortality occurring from insects and disease, primarily in the larger trees, and limited regeneration of shade intolerant tree species such as western white pine and Jeffrey pine.

Stands within the Alpine Meadows ski area would benefit by the removal of diseased trees and a reduction in stand density. When thinning trees where annosus root disease is present, it is beneficial to create a mix of tree species and sizes while limiting the number of true fir or mountain hemlock. In addition, when selecting trees for removal, preference should be given to trees infected with dwarf mistletoe, root disease and trees infested with bark beetles. For root diseases, it is reasonable to use the condition of the crown as an indicator of advanced decay. Although not always caused by root decay, a thin crown does indicate poor tree vigor. A tree with reduced photosynthesis is not able to maintain healthy roots as well as a tree with a full and healthy crown. In the presence of root disease, unhealthy roots will likely be overcome with decay faster than vigorously growing roots. For this reason, the thinner the crown of a tree in an area where root disease is present, the more likely it is that the roots have been weakened by decay.

Special consideration needs to be given to western white pine in the Alpine Meadows area. White pine blister rust, a non-native pathogen, has continued to weaken and kill this species over most of its range since its introduction into the Pacific Northwest in 1910. Identification and protection of local rust resistant trees for seed collection, if not already occurring, will aid in the future planting of rust resistant seedlings. Planting selected openings created through thinning operations with rust resistant stock would help insure this species persists in the area.

Treatment Alternatives

Do nothing: The no management alternative would allow the older and more decadent western white pines and true firs to continue to succumb to various pathogens and bark beetles. The necessity to remove high numbers of dead hazard trees on an annual basis will continue and likely increase during periods of drought. Stand density will continue to increase over time, consisting mostly of small diameter red fir, with high rates of mortality of mature trees infected with dwarf mistletoe, root disease and blister rust. High levels of tree mortality, for all size classes and species, caused by bark beetle attacks can be expected during extended periods of below normal precipitation. Areas of regeneration will be dense and dominated by shade tolerant species. This regeneration will grow slowly due to tree competition, infection by annosus root disease, spread by adjacent infected stumps and live and dead trees, and infection by dwarf mistletoe, spread by adjacent infected overstory live trees. Western white and Jeffrey pine will occupy an even smaller percentage of the stands due to limited regeneration and mortality of mature trees. Fuel loads will continue to increase creating a higher risk of stand replacing fire. Over time, this trend will result in stands that are more densely stocked with smaller diameter trees and have extremely heavy fuel loads.

Thin from below: Thinning from below to a basal area that is 80% of "normal", will reduce tree competition and, to some extent, increase the health and vigor of remaining trees. However, it will not eliminate the pathogens that are currently infecting the trees. Dwarf mistletoe, annosus root disease, and cytospora canker will continue to spread and intensify in the true firs causing tree stress and loss of vigor and infecting any true fir regeneration that becomes established. Blister rust and heart rot will continue to negatively affect the health of western white pine. Bark beetles will continue to attack these weakened trees and may cause significant mortality during periods of drought. The number of hazard trees removed each year will not change significantly and will likely increase during periods of drought. Western white and Jeffrey pine regeneration will be limited due to shading and competition from true firs and regeneration of all species will be subject to damage from people skiing and snowboarding through thinned stands if no protection is provided such as signing or snow fencing.

Thinning from below combined with a sanitation harvest: Thinning from below to a basal area that is 80 % of normal combined with the removal of diseased trees would greatly improve stand health. Sanitation harvesting would have to include the removal of selected large trees and groups of trees to be the most effective at reducing or eliminating pockets heavily infected with dwarf mistletoe and/or annosus root disease. Openings created within

true fir stands could be planted to non-host species such as rust resistant western white pine, lodgepole pine and/or Jeffrey pine since these species are not hosts for the fir strain of annosus root disease or fir dwarf mistletoes. However, planting western white pine should be avoided in some areas if mountain hemlock dwarf mistletoe is still present in adjacent overstory trees. Regeneration would have to be protected from skiers with snow fencing or signing. The reduction in stand density, the removal of trees infected with pathogens and the planting of non-host species, should improve stand conditions over time resulting in fewer trees being attacked and killed by bark beetles. A complete treatment of this type would also decrease the amount of fuel loading and reduce the number of hazard trees.

It is important to note that when implementing tree removal or hand thinning in a recreational site, Region 5 direction calls for the treatment of all conifer stumps with a registered borate compound to reduce the probability of infection by annosus root disease. Care also needs to be taken to minimize soil compaction and the wounding of residual trees.

Despite the effectiveness of any long or short-term plans to prevent tree mortality, some trees, through declining health, will eventually become hazards to the public. To minimize the risks associated with hazard trees, they should be identified and removed before they fail. The current practice for many National Forest is to remove trees as they die. This eliminates the risk from dead trees but fails to address living trees that are infected with root disease, heart rot, and/or have a structural defect. These high-risk green trees are equally hazardous and should not be overlooked. Therefore, it is recommended that the District develop a hazard tree evaluation and monitoring plan for the ski area. At your request, Forest Health Protection can provided information and assist with the development of this plan. In the short-term, trees within the ski area that have obvious stem decay, dead tops and/or large dead branches should be carefully evaluated and hazards removed or pruned as soon as possible. All standing dead trees within striking distance of facilities or areas frequented by skiers should be removed before the ski resort opens this winter.

Conclusion

Any future modifications to the Alpine Meadows Ski Area should incorporate a long-term vegetation management plan that includes a hazard tree evaluation and monitoring plan for recreation areas. The recommendations provided in this evaluation combined with input from the District and/or Forest silviculturist will help insure the continued presence of healthy trees that will provide visual/aesthetic qualities.

Forest Health Protection can assist with funding for thinning and removing green material from overstocked areas within and adjacent to the Alpine Meadows Ski Area on a competitive basis. Funding is also available on a competitive basis for treating dwarf mistletoe infected stands, including the pruning of infected limbs. If you are interested in this funding please contact any of the Forest Health Protection staff for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431 or Bill Woodruff at 530-252-6680.

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Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae*, attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 8 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

Evidence of Attack

The first sign of beetle-caused mortality is generally discolored foliage. The mountain pine beetle begins attacking most pine species on the lower 15 feet of the bole. Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes on successfully infested trees are pink to dark red masses of resin mixed with boring dust. Creamy, white pitch tubes indicate that the tree was able to "pitch out" the beetle and the attack was not successful. In addition to pitch tubes, successfully infested trees will have dry boring dust in the bark crevices and around the base of the tree. Attacking beetles carry the spores of blue-staining fungi which develop and spread throughout the sapwood interrupting the flow of water to the crown. The fungi also reduces the flow of pitch in the tree, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the needles to discolor and the tree to die.

Life Stages and Development

The beetle develops through four stages: egg, larva, pupa and adult. The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Females making their first attacks release aggregating pheromones. These pheromones attract males and other females until a mass attack overcomes the tree. The adults bore long, vertical, egg galleries and lay eggs in niches along the sides of the gallery. The larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

Conditions Affecting Outbreaks

The food supply regulates populations of the beetle. In lodgepole pine, it appears that the beetles select larger trees with thick phloem, however the relationship between beetle populations and phloem thickness in other hosts has not been established. A copious pitch flow from the pines can prevent successful attack. The number of beetles, the characteristics of the tree, and the weather affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include nematodes, woodpeckers, and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and pine mortality increases.

Annosus Root Disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of *H. annosum* have major differences in host specificity. All isolates of *H. annosum* from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the "S" group. This host specificity is not apparent in isolates from stumps; with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Western Gall Rust

Western gall rust (Peridermium harknessii) causes branch galls and trunk cankers on nearly all species of hard pines. The rust fungus produces yellow to orange-colored spores (aeciospores) on the surface of the galls during cool, moist, spring weather the second or third year after infection. New crops of spores are produced yearly thereafter until the host tissue dies. Dispersal of spores by wind occurs usually in May and June. After spores land on susceptible tissues, especially after rainfall, some germinate and cause new infections. Most infections occur on current-year shoots. There is considerable yearly variation in the amount of infection in the West, where abundant infection in given stands occurs in relatively few years.

The fungus infects pines of all sizes and ages. Seedlings are the most susceptible and are often killed within a few years by girdling stem galls. In nurseries, galls may develop on seedlings as a result of infection by spores from surrounding infected stands and windbreak trees. Branch infections on mature trees usually are of slight importance; however, branch infections of highly susceptible trees may exceed 100 galls and consequently would reduce growth potential. Stem infections can result in growth loss and cull. Galls resulting in cankers may continue to grow slowly for more than 200 years eventually resulting in stem deformity. Cankers form weak points making stems and branches susceptible to wind breakage. Cankers also create avenues through which decay fungi can enter stems.

Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.