Forest Health Protection
Pacific Southwest Region

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To: Darlene Koontz, Park Superintendent, Lassen Volcanic National Park

Subject: Evaluation of Insect and Disease Activity in the Summit Lake Campgrounds, Lassen Volcanic National Park (NE07-05)

At the request of Jon Arnold, Forester, Lassen Volcanic National Park, Danny Cluck, Forest Health Protection (FHP) Entomologist, and Bill Woodruff, FHP Plant Pathologist, conducted a field evaluation of the Summit Lake Campgrounds on August 28, 2007. The objective of the visit was to evaluate the current forest health conditions within and adjacent to campsites and to provide management recommendations as appropriate. These recommendations will assist with planning future activities, including campground renovations and vegetation and hazard tree management within the recreation area. Jon Arnold accompanied us in the field.

Background

Summit Lake (Figure 1) is near the center of Lassen Volcanic National Park and adjacent to State Highway 89 (T30N, R5E, Section 4) at an elevation of 6700 feet. Precipitation for the site averages 70 - 90 inches per year. The campgrounds are located on the north and south ends of the lake in a predominately red fir (*Abies magnifica*), mountain hemlock (*Tsuga mertensiana*) and lodgepole pine (*Pinus contorta var. murrayana*) forest. Western white pine (*Pinus monticola*) also occurs throughout the area and is more prevalent upslope from the campgrounds. All stands contain an overstory of large, decadent trees (mostly red fir) and a relatively healthy mid-story layer with dense pockets of small diameter trees in the understory (mostly red fir and western hemlock). The management objectives for this recreation area are to promote and maintain the presence of healthy trees, reduce the occurrence and spread of root disease and reduce the number of hazard trees.

Fig. 1 Summit Lake, looking NE across Hwy 89

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Observations

Lodgepole pine dwarf mistletoe (*Arceuthobium americanum*) has infected a few lodgepole pines within the campground causing bole and limb swelling and branch brooming. Near the south campground, western gall rust (*Peridermium harknessii*) was found infecting two lodgepole pines, resulting in bole cankers. One tree had snapped off near the canker. In the north campground, fresh mountain pine beetle (*Dendroctonus ponderosae*) attacks were observed on two live lodgepole pine trees.

Western white pines in the area appear to have various levels of white pine blister rust (*Cronartium ribicola*) infection, causing branch dieback and thin crowns. A few western white pine have been killed by mountain pine beetle within and adjacent to the campground.

One or more species of brown rot fungi were observed in red fir, western white pine and mountain hemlock causing extensive heartwood decay, especially in older trees (Figs. 2 and 3) Many of these infected trees, and recently cut stumps of infected trees, have old scars at the base (unknown cause) that may have served as entry courts for the decay fungi.

Fig. 2 Bole damage w/ brown rot

Fig. 3. Brown rot in red fir log

Large diameter red firs appear to have several biotic agents working against them such as red fir dwarf mistletoe (*Arceuthobium abietinum* f.sp. *magnificae*), cytospora canker (*Cytospora abietis*) brown heartwood decay (species unknown), Indian paint fungus (*Echinodontium tinctorium*), and wood boring beetles (Family: Cerambycidae). A few of the smaller red fir trees have heavy dwarf mistletoe infections and cytospora canker infections (Fig. 4). Although no *Heterobasidion annosum* conks were found, annosus-like decay was observed in stumps and exposed fir roots (Fig. 5). Therefore, it is likely that fir (s-type) annosus root disease is present in both campgrounds. At this time, the level of annosus root disease appears low, base on the healthy appearing foliage on most of the trees. A few of largest trees have died within the past several years and were subsequently removed. The remaining large diameter red firs are generally showing a gradual crown decline (Fig. 6), mostly due to high levels of dwarf mistletoe infection and possibly annosus root disease. Despite the level of heartwood decay and the likely presence of annosus root disease there is very little blow down in the area.

Fig 4. Cytospora branch flagging w/ dwarf mistletoe

Fig 5. Stump with annosus-like decay

Fig 6. Declining red fir

Mountain hemlock, lodgepole pine and red fir trunks in several campsites have been injured by campers chopping, sawing or throwing hatchets at them. A few of these trees suffered a moderate amount of cambium damage as a result. Lastly, the soil appears to be compacted in some areas but this does not appear to be negatively affecting tree health.

Discussion

Trees in the Summit Lake Campgrounds, like most forested campgrounds, are exposed to additional stress factors that can compromise their health and vigor. Firewood collecting sometimes leads to tree wounding from hatchets and saws. Carving and chopping trunks causes extensive cambium damage and foot and vehicle traffic increases soil compaction and can damage roots. Furthermore, leaving vegetative screening between campsites often results in overstocking of understory trees.

Dwarf mistletoe infections and mountain pine beetle activity in lodgepole pine, dwarf mistletoe and possible *H. annosum* root decay in red fir, and heartwood decay (unknown fungi) in all species are the most serious conditions identified in the Summit Lake area. Several large trees have been felled over the years that had previously succumbed to some combination of dwarf mistletoe, root disease, heartwood decay, wood borers and bark beetles. Some of these trees were probably hazardous before they died. Since large trees with human or property targets are continuing to decline at Summit Lake, it is critical that they are frequently evaluated so that potential hazards are identified before injury or damage occurs. Treatment for a hazard tree (a defective tree within striking distance of a target) is to remove the tree, move the target or keep people away. The most effective ways to keep people away from a hazard trees is to move the facility (picnic table, campsite, toilet, parking area, etc.) or construct barriers around the trees.

Identifying hazards by signing is often ineffective in keeping people away and generally does not relieve an agency from liability for injury or damage caused by known tree hazards. Liability can only be eliminated by closing hazardous areas or removing the hazard. Liability can be minimized by implementing an on-going tree hazard identification and treatment program for recreation areas. This program would involve periodically examining trees in recreation areas, removing or mitigating those deemed hazardous and monitoring questionable trees over time. A conscientiously applied hazard tree program is currently in practice at Lassen Volcanic National Park.

For trees with many dead branches, large bole/branch swellings (with broken bark), or large dying brooms, consideration should be given to tree removal or branch pruning to remove hazardous limbs. Removing dwarf mistletoe infected limbs will reduce the number of seeds that can disperse and infect susceptible understory trees. Depending on the level of dwarf mistletoe infection, removal of infected limbs can improve the health and vigor of the tree as long as at least 50% of the original live crown remains after treatment.

Tree wounding by careless campers is occurring at Summit Lake. To help prevent human caused tree injuries, which have the potential of creating hazard trees and tree mortality, a public awareness poster should be placed at the campground entrance to inform campers about the importance of trees to the area and the problems associated with tree wounding from hatchets, axes, saws, knives and nails.

Stands within the Summit Lake campground would benefit by the removal of red fir that are severely infected with dwarf mistletoe (and possibly root disease) and pruning of red fir with lower levels of dwarf mistletoe infection. Large tree removal would create openings that could be planted with western white pine, lodgepole pine and mountain hemlock which are not hosts to red fir dwarf mistletoe. If signs of annosus root disease are present near these openings, the planting of mountain hemlock should be avoided as it is also susceptible to the s-type annosus root disease.

Lodgepole pine appears to be overstocked in several pockets in and around the campground. These pockets would benefit from a reduction in stand density through thinning. Removing individual trees that are currently infested with bark beetles, heavily infected with dwarf mistletoe or that show signs of bole decay should be the top priority for any live tree or hazard tree removal project. In general, pure lodgepole pine stands should be thinned to 80 to 100 sq.ft. BA to reduce their susceptibility to bark beetle attacks. However, excessively reducing the basal area in dense stands in one entry can result in wind throw and/or snow breakage of residual trees. To become windfirm, trees need to be gradually exposed over many years to increasing wind forces. This can be achieved by gradually opening up groups of dense trees with multiple thinnings conducted over several decades. Mixed stands of lodgepole pine and red fir may be able to sustain higher stocking levels. In either case, site productivity should be determined and trees thinned to stocking levels appropriate for management objectives. To reduce the susceptibility to future bark beetle related mortality, stands should be thinned to densities that are 80% or less of “normal”, effectively reducing tree competition for water, nutrients and sunlight.

Dense stands surrounding campgrounds would also benefit from thinning. In addition to increasing tree vigor, thinning can reduce the risk of damaging wildfire and provide a more defensible space for protecting the campground. When planning such thinning, it should be recognized that this is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pine, should benefit by having the stocking around them reduced to lower levels.

Recent Forest Health Protection aerial and ground surveys have shown a dramatic increase in mountain pine beetle caused lodgepole pine mortality throughout northeastern California. Dry conditions combined with dense stands of larger diameter trees (> 8” DBH) have created ideal conditions for localized mountain pine beetle outbreaks. To prevent mountain pine beetle related mortality in the short term two direct control management options exist: 1) removal of green infested lodgepole pine; or 2) applications of insecticides to un-infested tree boles. Although there is no general agreement regarding the effectiveness of direct control of mountain pine beetle, some success has been observed in Donner Camp, Tahoe National Forest. To implement this management option, green infested lodgepole pine must be identified and removed promptly. This would require annual or bi-annual tree inspections and subsequent removal of infested trees prior to beetle emergence. The second short-term preventative measure would be the use of insecticides on tree boles. All non-infested trees greater than 8” DBH in the campgrounds would be treated with a registered pesticide by spraying as much of the bole as possible. To be effective, trees would need to be treated prior to being attacked by the first beetle flight (ie. before May 2008). Insecticide treatments can provide protection up to two years against bark beetle attacks giving the Park time to develop and implement long-term strategies to reduce overall tree susceptibility. Consideration needs to be given to the choice of insecticide since the campgrounds are in close proximity to Summit Lake.

Western white pine should be retained as much as possible during any thinning operation in order to preserve genetic diversity for resistance to white pine blister rust (*Cronartium ribicola*). 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 will aid in providing rust resistant seedlings if needed for future management. Planting selected openings created through thinning operations with rust resistant western white pine would help insure its survival in this area.

It is important to note that when implementing tree removal or hand thinning in a recreation area, it is important to treat conifer stumps with a registered borate compound to reduce the probability of infection by *Heterobasidion annosum*, the causal agent of annosus root disease. Treating all stumps would provide the best protection against the creation of new root disease centers but time and funding will likely dictate what level of treatment actually occurs. At a minimum, all stumps greater than 8”dbh should be treated. Care also needs to be taken to minimize both wounding of residual trees and site disturbance.

Despite the effectiveness of any long or short-term plans to prevent tree injury and mortality, some trees, through declining health, will eventually become hazards. To minimize risk, hazard trees should be identified and removed before they fail. The current practice for many campgrounds 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 other structural defects. These high-risk green trees are equally hazardous and should not be overlooked. In the short-term, trees within Summit Lake Campground that have obvious stem decay, dead tops and/or large dead branches should be carefully evaluated. Known hazards must be removed or mitigated as soon as possible. All standing dead trees within striking distance of campsites or campground facilities should be removed immediately. The current monitoring program in the Park is attempting to identify and treat all hazard trees in recreation areas.

Any future modifications to the Summit Lake Campground should incorporate a long-term vegetation management plan. The recommendations provided in this evaluation combined with specific vegetation management input from LVNP will help insure the continued presence of healthy trees.

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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General Recommendations for Campground Construction and Vegetation Management

Maintaining and promoting healthy trees are important objectives for development plans in campgrounds. Care should be taken during future campsite, trail and facility construction to minimize negative impacts on the landscape. The following guidelines should be applied for areas under construction or in areas where future construction will take place.

- Tree density should be appropriate for the site. This will provide access to light, moisture and nutrients and allow the trees to better cope with their altered environment.
- Trees that will directly interfere with structures or that will be seriously damaged during construction or excavation should be removed.
- Leave a mixture of ages and species to provide a continual forest canopy over the years.
- Fence off individual or groups of trees before construction to negate or minimize root damage by soil compaction or trunk and root damage by equipment. Protective fences should be placed, at a minimum, at drip line. Depending on the species, tree roots can exist within a radius two times the crown radius and encompass an area well beyond drip line. Drip line is defined by the outer edge of the foliage. Penalties for damaging trees should be incorporated into tree removal or construction contracts.
- Road or lot grades should be changed as little as possible. Grading damages roots and can set up conditions that favor soil erosion. It can also alter the contour such that the flow of surface and subsurface water is drastically affected.
- Trenches should always be dug away from tree roots.
- Do not back fill with earth or rocks around the trunks of trees.
- Avoid paving with either concrete or asphalt over root systems, or close to the trunks of trees.
- Use caution in applying wood preservatives and other chemicals to buildings. Trees and other plants have been killed by direct contact with them or as a result of their runoff in rainwater.
- Avoid leaving green pine slash on site to prevent the build up of pine engraver (*Ips pini*) beetle populations that may attack standing green trees.

Future construction or vegetation management activities that incorporate the above guidelines will help assure the existence of vigorous and healthy trees following project completion.

Insect and Disease Information

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.

H. annosum in western North America consists of two host-specific forms, the ‘s-type’ and the ‘p-type’. Isolates of H. annosum from naturally infected ponderosa pine, Jeffrey pine, sugar pine, western white pine, lodgepole pine, Coulter pine, incense cedar, western juniper, pinyon pine, and manzanita have been the p-type. Isolates from true fir and giant sequoia have been the s-type. This host specificity is not apparent in isolates from stumps, with the s-type 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 several decades. 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 mistletoe commonly predisposes true firs to Cytospora abietis canker, which can girdle and kill branches and occasionally kill trees.

Dwarf mistletoes spread by means of seed. During Fall, the ripening single-seeded fruit swells as the internal liquid pressure increases to the point of bursting the tiny fruit. The expoding fruit forcibly propels the seed as far as 60 feet. The seed is covered with a sticky substance and adheres to whatever it contacts. For infection to occur, the seed must stick to a needle or twig and then be moved by winter rain or snow to the base of a needle. 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 after 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, in still air, the seeds can travel a horizontal distance equal to the height in the tree from which it is launched. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread of most dwarf mistletoes within tree crowns usually averages less than one foot per year because of foliage density. Thus a lightly infected conifer on a good site can grow in height faster than dwarf mistletoe can spread up its crown. Such trees can survive dwarf mistletoe as long as they are not further infected from overstory trees or girdled by bole infections. An exception to this is gray pine or other conifers with sparse foliage. In gray pine, the vertical rate of dwarf mistletoe spread has been measured to be 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 signs of infection are generally exposed to view within a tree's crown. Signs include 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. Since dwarf mistletoes require 2-4 years to form aerial shoots after infection, new infections are not apparent until the shoots appear.

Cytospora Canker of True Firs

Cytospora abietis is a damaging, canker-inducing fungus that commonly occurs on true firs throughout their natural range in California, central and eastern Oregon, and frequently on firs and Douglas-fir elsewhere in the western United States. A weak parasite, it attacks only trees that have been debilitated by other disease-causing agents, drought, fire, insects, and human activities.

One of the important factors that predisposes firs to infection by C. abietis is dwarf mistletoe. Practically all fir stands in California and Oregon infested with dwarf mistletoe are infested with this fungus. C. abietis more commonly infects branches invaded by dwarf mistletoe; in some stands, nearly a fourth of all branches bearing mistletoe are infected. Thus, in mistletoe-infected fir stands, considerable branch killing occurs each year as a result of this canker organism and occasionally trees are killed. Because this fungus sometimes reaches damaging proportions, C. abietis can constitute a threat to the management of true firs.

White Pine Blister Rust

White pine blister rust is caused by Cronartium ribicola, a non-native obligate parasite that attacks 5-needled pines and several species of Ribes. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes. The disease occurs throughout the range of western white pine and sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on tree bole or branch cankers are wind-disseminated to Ribes where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves re-infect other Ribes throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on Ribes leaves in the fall. Teliospores germinate in place to produce spores (sporida) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes, its spread from Ribes back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers with margins more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result.

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.