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Evaluation of Insect and Disease Conditions in the North Shore Project Analysis Area, Lake Tahoe Basin Management Unit

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BACKGROUND

In 1995, the Lake Tahoe Basin Management Unit (LTBMU), initiated preparation of a Draft Environmental Impact Statement to analyze alternative ways to manage approximately 8,000 acres on the north shore of Lake Tahoe. The proposed project area includes lands between the urbanized lakeside zone and the LTBMU watershed boundary from the Truckee River corridor east to Incline Creek. On July 18-20, 1995, John Wenz, Entomologist, and John Pronos, Plant Pathologist, Forest Pest Management (FPM), South Sierra Shared Service Area, conducted an evaluation over part of the project area. The purpose of the evaluation was to identify the major insects and pathogens active in the area and provide relevant insect/pathogen-related information for inclusion in the North Shore Project (NSP) DEIS.

OBSERVATIONS

Observations were made at 11 locations within the NSP area (see Figure 1- Map; Table 1- List of Locations). The major insects and pathogens found and their coniferous hosts are given in Table 2. The following discussion is organized by specific insect or pathogen. Insect and pathogen biologies are provided in Appendix 1.

INSECTS: As is generally the case with other areas in the Lake Tahoe Basin, bark and engraver beetles are the most important insects currently affecting the vegetation. With the exception of light-to-moderate tent caterpillar feeding on bitterbrush, no noteworthy defoliator activity was observed.

Bark and Engraver Beetles:

1) Fir Engraver, Scolytus ventralis (Coleoptera: Scolytidae). True fir mortality, top-kill and branch dieback associated with fir engraver activity was observed scattered throughout the area in mixed confier and fir stands. Woodborers, probably the roundheaded fir borer, Tetropium abietis (Coleoptera: Cerambycidae) and/or the flatheaded fir borer, Melanophila drummondi (Coleoptera: Buprestidae) were frequently found in the lower bole of fir, particularly red fir, killed by the fir engraver. Evidence (adult galleries) of other Scolytus spp. was found in the upper boles and branches of down fir trees and broken tops. Current top-kill and mortality was scattered throughout the mixed conifer and fir stands but relatively high levels of fir mortality and top-kill has occurred in the area over the past 4 to 6 years. Based on needle retention and bark condition in the top-killed portion of the tree, it was apparent that many individual fir trees had been attacked and then re-attacked by subsequent generations of the fir engraver. Fir engraver attacks that top-kill less than 20 to 30% of the crown do not necessarily result in death of the entire tree, particularly if the tree is otherwise healthy. However, if the the initial attack and/or subsequent re-attacks kill more than about 30% of the crown, the tree is not likely to recover.

Stocking levels in the North Shore mixed conifer and fir stands evidencing fir mortality were variable frequently ranging from about 270 sq.ft./acre to 360 sq.ft./acre of basal area. Both overstory and understory fir were attacked by the engravers often in stands where dwarf mistletoe and Cytospora canker were prevalent. The condition of the host tree can be one factor influencing successful beetle attack. Trees weakened by predisposing factors such as diseases, between-tree competition due to overstocking, physical injury and/or moisture stress, are more likely to be successfully attacked than healthy trees. Thus, regulation of stocking through vegetation management (including thinning), in combination with the mitigation of other predisposing factors, should allow trees to grow as vigorously as possible and reduce chances of successful bark and/or engraver beetle attack.

2) Mountain Pine Beetle, Dendroctonus ponderosae (Coleoptera: Scolytidae). Some mountain pine beetle-related mortality was observed in lodgepole pine stands generally restricted to wet or riparian areas. Mountain pine beetle was also observed killing scattered, individual, sugar pine.

3) Jeffrey Pine Beetle, D. jeffreyi. Scattered, individual tree and a few small groups (<10 trees/group) of Jeffrey pine beetle-related Jeffrey pine mortality were present in the lower elevation pine stands. In general, Jeffrey pine mortality in the North Shore area appeared less than that which has occurred over the past several years in East and South Shore areas. Red turpentine beetle (D. valens) were found in the base of some Jeffrey pine but at very low levels. Pine engraver (Ips spp.) activity was also very low.

Defoliators:

Light-to-moderate tent caterpillar, Malacosoma sp. (Lepidoptera: Lasiocampidae) feeding on bitterbrush, Purshia sp. (Rosaceae), was observed in relatively open areas with numerous host plants. Tent caterpillar populations periodically

increase to outbreak levels that generally last from 2 to 4 years but have reportedly not caused serious, longterm, adverse effects.

PATHOGENS (generally listed in order of decreasing frequency and potential for causing damage)

Dwarf Mistletoes:

Red fir dwarf mistletoe (Arceuthobium abietinum f.sp. magnificae) was the most common of these parasites, followed by white fir dwarf mistletoe (A. abietinum f. sp. concoloris) and very small amounts of lodgepole pine dwarf mistletoe (A. americanum). No mistletoe was found on Jeffrey pine. The distribution of dwarf mistletoes at North Shore was typically irregular. Infections at a given site could vary from none to severe. Most stands of true fir in the project area were multi-storied, and in some, dwarf mistletoe was present at significant levels in all age classes of trees. On sites with mistletoe, normally only one species was infecting a single species of conifer host.

Whenever present, dwarf mistletoe should be considered in the management of that site. Moderate to heavy infections eventually weaken trees so that they are more vulnerable to drought stress and insect attack. A variety of silvicultural treatments can be used to effectively control these parasites. Lightly infected stands are the easiest to treat and require the least radical steps. One of the most difficult situations to manage is when dwarf mistletoe is well established in uneven aged stands. Because of its disperal mechanism, it is almost impossible to maintain a vigorous overstory and understory when both are infected.

Annosus Root Disease:

This root disease is caused by the fungus Heterobasidion annosum, and was repeatedly found affecting true fir in the North Shore area. Pine species were free of root disease. Every sparsely stocked small opening that had large, old stumps and evidence of fir mortality occurring over a long period of time had signs and symptoms of root disease. In most cases the fungus was acting as a butt rot. It was not causing obvious mortality, except in seedling and sapling size fir, and it did not appear to have caused much windthrow. Depending on management objectives, the effects of this root disease can be considered either desirable or undesirable.

In unmanaged true fir and mixed conifer stands, H. annosum usually exists at low levels as a natural part of the ecosystem. Entering these stands to harvest green timber, build roads, establish campgrounds, or salvage dead trees tends to increase the amount of annosus root disease by creating convenient entry points (stump tops and wounded trees) for the fungus. Thus, we find this root pathogen most concentrated on sites where trees have been repeatedly removed. Pesticides containing borate compounds (borax, Sporax) applied to stump tops are very effective in preventing the start of new annosus root disease centers. These materials, however, do not stop the underground spread of this root disease pathogen once it has become established, nor are they

effective for treating basal wounds created during harvesting. Improving logging practices is the best way to prevent tree damage.

Cytospora Canker:

A fungus (Cytospora abietis) causes this disease which can kill small firs and the branches of larger trees. It is a weak parasite that attacks trees already stressed by other factors. This organism, in association with dwarf mistletoe, is responsible for much of the branch "flagging" common in recent years to many areas in the Sierra Nevada. Branches with dwarf mistletoe are infected by Cytospora and eventually die. The ultimate effect of this canker is to reduce the amount of live crown on true fir which may lead to reduced tree vigor and predisposition to insect attack.

White Pine Blister Rust:

This disease is caused by the non-native fungus Cronartium ribicola, which can be especially lethal to small 5-needled pines. It was found infecting sugar pine in two North Shore units and western white pine in a third unit. While the frequency of this pathogen is not currently high, the amount of sugar and western white pines in the project area is also rather low. Over the period of several decades, blister rust can eliminate most seedlings and saplings of susceptible species, and will continue to kill natural regeneration as it is produced. This results in stands with only large sugar pines (they may be infected but not always killed) and no replacements. The best way to ensure sugar pine seedling survival is to plant trees with genetic resistance to this disease.

Yellow Witches-Broom:

This is another disease caused by a rust fungus (Melampsorella caryophyllacearum that primarily infects white fir in the Sierra Nevada. It produces conspicuous densely branched witches-brooms with very short yellowish needles. The effect is mostly cosmetic with little damage to the host tree. The witches-brooms may be mistaken for dwarf mistletoe infections by those unfamiliar with this disease.

MANAGEMENT ALTERNATIVES

The following insect and disease management alternatives are not mutually exclusive. They are intended to be considered for integration into overall LTBMU vegetation management plans and forest health activities. Several of the alternatives (e.g., regulation of stocking, regulation of species composition, sanitation) provide opportunities to reduce undesirable effects of both insects and pathogens. Combination of the alternatives may be implemented depending on the insects/pathogens present and location-specific management objectives.

1. No Management. The high levels of insect/pathogen-related mortality experienced in the North Shore and other areas of the Lake Tahoe Basin over the

past several years is a consequence of the interactions between weather (drought), current stand conditions and insects and diseases. If no direct and/or indirect actions are taken to change or mitigate factors associated with undesirable insect and pathogen effects, it is likely that relatively high mortality and top-kill will continue on a fluctuating, periodic, basis. This may be particularly evident in stands with a high proportion fir due to a combination of dwarf mistletoe, annosus root disease and fir engraver. Such mortality increases the amount of standing dead and down woody material which may affect the need/opportunity for salvage and result in increased dead fuels, increased wildlife habitat for snag and down woody material dependent species, increased decomposition and nutrient cycling and, depending on location, the creation of hazardous trees.

2. <u>Bark/Engraver Beetle Management</u>.
The following management options may be considered for bark and engraver management: (A) direct suppression; (B) regulation of stocking; (C) regulation of species composition and D) disease management.

A) DIRECT SUPPRESSION. Direct control of Jeffrey pine beetle through the removal of infested trees has been circumstantially shown to be effective in reducing subsequent Jeffrey pine beetle-related mortality in developed recreation sites in the Lake Tahoe Basin. Efficacy probably increases if infested trees are removed annually or over several consecutive years. Under most circumstances in California, direct control has not been shown to be consistently effective in controlling area-wide populations of other bark/engraver beetles such that subsequent mortality is reduced to acceptable levels.

B) REGULATION OF STOCKING. The purpose of stocking control is to thin overstocked stands and vegetation aggregations to levels appropriate for the site. From the bark/engraver beetle perspective, the intent is to create and maintain healthy vigorously growing trees and stands that have an increased chance of preventing successful attacks. Much of the bark/engraver beetle-related mortality on the North Shore has occurred in stands with basal areas ranging from about 270 sq.ft./acre to 360 sq.ft./acre. Work with pine bark beetles from several areas in the west indicates that reducing stocking to about 55% to 75% of normal basal area effectively reduces mortality.

C) REGULATION OF SPECIES COMPOSITION. Some of the fir engraver-related mortality occurred in mixed conifer stands that currently have a relatively high proportion of fir, primarily white fir. Many of these stands may have historically had a higher proportion of pine. Increasing the amount of pine in these stands will, through time, reduce host availability for the fir engraver and increase species diversity at the stand level. If also managed for other predisposing factors (e.g., stocking levels, diseases), bark and engraver beetle-related mortality should be reduced.

D) SANITATION/DISEASE MANAGEMENT. In addition to regulating stocking and species composition, removal of selected poorly growing, unthrifty trees, that will not likley respond to thinning should improve overall stand vigor and reduce the potential for bark/engraver beetle attack. This can include removing trees with physical injuries, poor needle retention, diseases [illegible] page [illegible]

[illegible] likely that [illegible] will [illegible] fluorescent [illegible] period [illegible] [illegible] production [illegible] [illegible] the [illegible] for [illegible]

[illegible] beetle-related [illegible] [illegible] [illegible]

[illegible] suppressed, [illegible] number of attacking [illegible] populations [illegible]

2) OTHER [illegible] control of [illegible] has been experimentally [illegible] in [illegible] mountain pine beetle-related [illegible] in the Lake Tahoe Basin. Efficacy [illegible] [illegible] Under [illegible] to be [illegible] effective in [illegible] control [illegible] levels.

[illegible] OF TREATMENT. The purpose of [illegible] [illegible] healthy [illegible] growing [illegible] and stands that [illegible] [illegible] preventive [illegible] beetle-related mortality [illegible] to about 272 [illegible] 80 ft.²/acre. [illegible] with [illegible] [illegible] reducing to about 35% [illegible] mortality).

[illegible] SPECIES COMPOSITION. Some of the fir engraver-[illegible] that [illegible] have a [illegible] primarily white fir. Many of these [illegible] a higher proportion of pine. Increasing [illegible] through time, reduce [illegible] increase of tree diversity at the [illegible] factors (e.g., [illegible] density [illegible] beetle-related [illegible] should be [illegible]

[illegible] regulating [illegible] of selected poorly growing, [illegible] (particularly dwarf mistletoe- see discussion below), live crowns of less than 20-30% of the tree height, current top-kill of more than 30% of the live crown, and current branch dieback that affects at least 50% of the live crown. The decision to remove individual or groups of trees through thinning and/or sanitation for insect/disease management purposes should be made within the context of overall resource management goals and objectives and the desired condition for the area.

3. Dwarf Mistletoe Management. As mentioned above, mistletoe infestations can be reduced each time a stand is entered for thinning or sanitation purposes. The steps required for control in a particular area depend on the severity of infection, which is determined by the distribution of mistletoe within the stand and how long it has been allowed to build up. Listed below are the most commonly used approaches for suppression.

A. OVERSTORY REMOVAL. One of the first rules for managing stands with dwarf mistletoe is to remove infected overstory trees in order to protect the understory. The only time infections in the overstory are tolerated is when there is no existing understory of susceptible species or when an understory of non-host species is to be established (species conversion). Removing infected trees from the overstory may not fit well when uneven aged management is a goal. Large trees can be killed and left standing if their use as wildlife snags is desired.

B. SANITATION THINNING. The most heavily infected trees are removed to reduce the overall effect of mistletoe, lower the risk of engraver beetle attacks, and increase the vigor of the residuals. For example, true fir with Hawksworth ratings of 5 or 6 have only a life expectancy of another 10-15 years, are growing very slowly, and are a major source of infection for adjacent trees. The overall health of most stands would increase with the removal of these trees. Released trees on good sites will outgrow the remaining mistletoe. It is not necessary to eliminate all mistletoe as long as no overstory source of mistletoe seed is present.

Dwarf mistletoe sanitation will also reduce the amount of Cytospora canker present in a stand because this canker is so closely linked with mistletoe infections. Trees with diseases like yellow witches-broom may also be targeted for removal during sanitation treatments.

C. ELIMINATE STAND AND REGENERATE. This treatment may be the only effective option for the most severely infected stands where no non-host species are present. By removing all hosts we eliminate this obligate parasite and are able to start over with disease-free trees.

D. REGULATE SPECIES COMPOSITION. Because dwarf mistletoes are host specific, altering the tree species composition in mixed stands can reduce or eliminate the negative long term impacts of this pest. Standard silvicultural procedures during normal entries can be used to accomplish this treatment. Planting also offers an opportunity to establish tree species resistant to any dwarf mistletoes that are present in adjacent trees or stands.

E. PRUNING. Removing the infected portion of a tree's crown is not normally economical in the general forest, but is commonly used in recreation and administrative sites where individual tree value is high. Selectively removing only witches-brooms from high value trees can increase tree vigor and prolong the life of these individuals, even though mistletoe remains in the crown.

F. USE BUFFER ZONES. Any management strategy for dwarf mistletoe should include steps to prevent the parasite from moving back into treament areas from adjacent infected trees. Buffer zones can occur naturally or be man made, and are any areas that do not contain host material susceptible to the mistletoe(s) present. Examples include: meadows, lakes, rivers, openings, clearings, roads, and plantings of non-host trees.

4. Root Disease Management.

A. SANITIZE AREAS AFFECTED BY ROOT DISEASE. Most of the fir within root disease centers are either already infected or will be in the future. A challenge with this root pathogen on true fir is that infected trees do not always show obvious above ground symptoms. This means that identifying root diseased trees and the boundaries of disease centers may be difficult. If true fir growth rates or mortality are unacceptable, consider removing all host trees within disease centers and convert to non-host species, such as Jeffrey pine and rust resistant sugar pine which presently are at low levels in most stands. Heterobasidion annosum will remain active on the site and may still move underground to nearby fir.

A more aggressive approach would be to sanitize the root disease centers and remove an additional strip of green host trees from the adjacent healthy stand. The intent here is to cut uninfected trees far enough in advance of annosus root disease to allow non-parasitic root inhabiting fungi to invade and colonize root systems. Essentially, this would deny H. annosum access to these roots, and the enlargement of centers would be stopped. Based on the size and spacing of fir in most of the North Shore Area, the buffer zone would have to be 80-100 feet wide. Treating all cut stumps with Sporax is necessary for the treatment to be effective.

B. SPORAX. This pesticide is effective in keeping annosus root disease from infecting freshly cut stumps, and therefore prevents the start of new disease centers. Sporax does not control H. annosum that is already established in roots. Use of this preventive pesticide is routine in many pine type situations, especially on the east side of the Sierra crest. Use of Sporax in true fir is less common, primarily because of the difficulty in identifying diseased areas and because the pathogen is already established in so many true fir stands. Still, Sporax will prevent the start of new disease centers, and its use in the North Shore Project Area should be considered wherever true fir will remain as a stand component. On the other hand, if stumps are not treated, the potential for introducing more root disease is created each time trees are cut. The easiest approach would be to treat all fir stumps, greater than 12 inches diameter, cut during harvest. It may be questionable to use Sporax within root disease centers where annosus is well established. If it is desirable to reduce

the amount of pesticide used or lower cost, Sporax treatment could be limited to areas free of root disease.

C. MINIMIZE DAMAGE TO RESIDUAL TREES. The following guidelines are intended to reduce injury to residual trees and thereby prevent future losses from wood decay, including annosus root disease. They were developed by the Pacific Northwest Research Station and the Region 5 Silvicultural Development Unit and should be considered whenever entering true fir stands.

1. Restrict time of logging. Do not allow entry during the spring and early summer when tree bark is loose and the likelihood of mechanical damage is greatest.

2. Restrict the size and type of logging equipment. Match the logging system to the topography and use the smallest size of equipment to get the job done. Use cable systems on slopes steeper than 35%.

3. Mark leave trees rather than cut trees. Marking crop trees makes them easier to see and avoid.

4. Lay out skid roads in advance of logging. Skid trails should not be cleared wider than the skidding vehicle. Use straight-line skid trails.

5. Leave buffer (bump) trees. When possible, leave cull logs and bump trees along the edges of skid trails. Remove bump trees during the last turn.

6. Limit log length. Relate log length to the spacing of the residual stand. The longer a log, the more likely it is to damage leave trees.

7. Log skid trails first. Cut the stumps in skid trails as low as possible, preferably 3-4 inches high.

8. Use directional falling. Fall trees toward or away from the skid trails to reduce skidder maneuvering.

9. Limb, top, and buck trees prior to skidding.

10. Do not thin stands of thin-barked trees too heavily. Sunscald after logging can cause considerable damage to thinned bark trees like true firs.

11. Work closely with contractor. Instruct operators in methods of reducing damage. Inform contractor that damage will not be tolerated. Communicate clearly the desired results to the contractor - close supervision may be necessary, especially with inexperienced operators.

5. __White Pine Blister Rust Management__. Any projects that involve tree planting create the opportunity to establish sugar pine seedlings that are genetically resistant to blister rust. This is the best strategy to ensure that sugar pine remains a component of stands in the Lake Tahoe Basin. Using non-resistant stock would probably result in survival of less than 10% (including no survival at all). Also, any activities that would increase the amount of __Ribes__ sp. in a stand or allow it to invade into a new area would increase the threat of blister rust.

Table 1. Specific Site Locations for Areas Evaluated During FPM Biological Evaluation, North Shore Project, July 18-20, 1995.

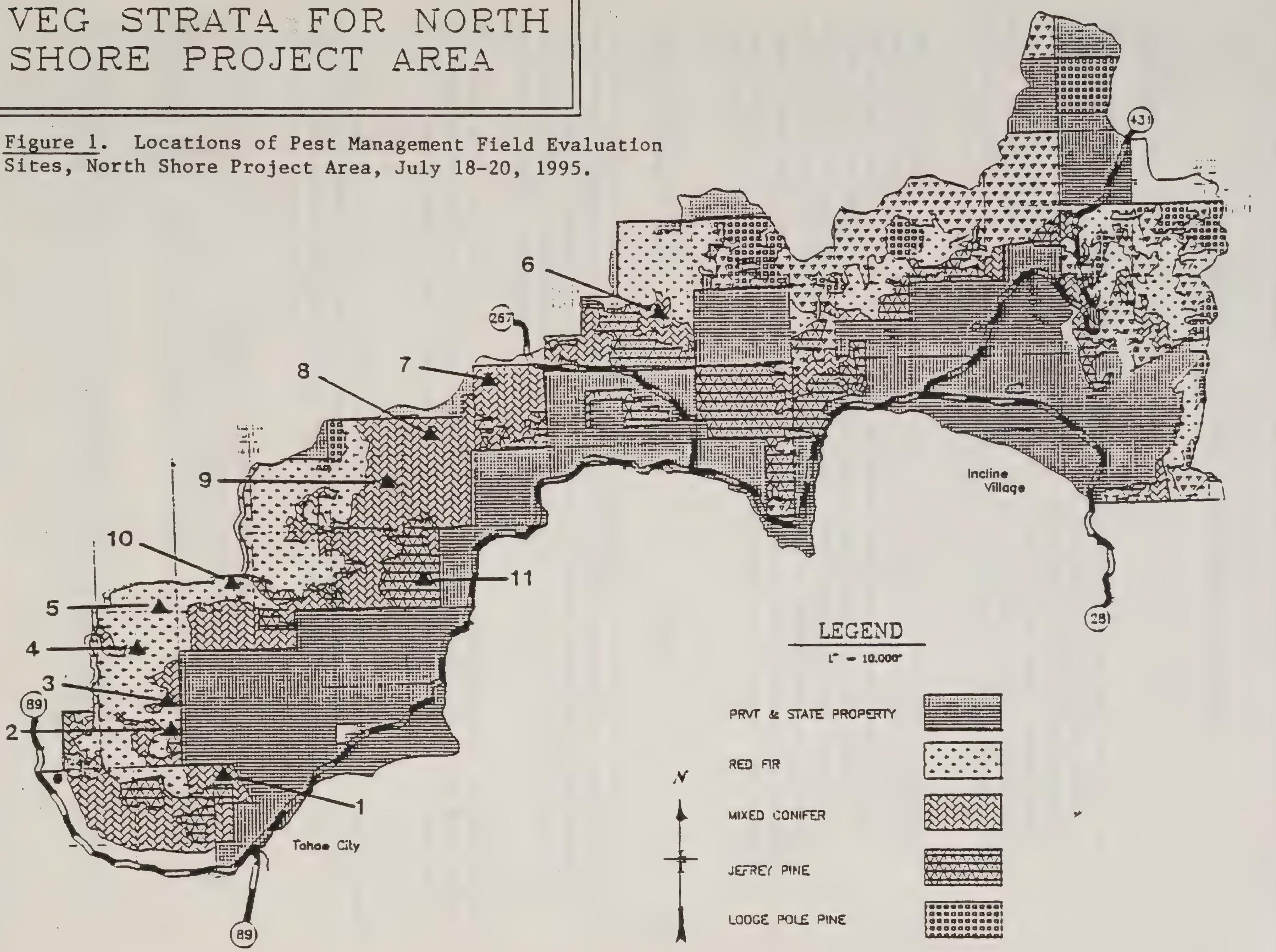
SITE NUMBER	LOCATION	
1	R17E T15N S6	Northwest
2	R16E T16N S35	Southeast
3	R16E T16N S35	Northeast
4	R16E T16N S26	Central
5	R16E T16N S26	North-central
6	R17E T16N S1	North-central
7	R17E T16N S10	Northwest
8	R17E T16N S8	East-central
9	R17E T16N S17	Central
10	R16E T16N S24	Southwest
11	R17E T16N S21	West-central

Table 2. Major Insects, Pathogens, and Associated Host Plants, by Site Found During the North Shore Project Biological Evaluation.

PATHOGENS	HOST PLANT	SITE
Dwarf Mistletoes		
Arceuthobium abietinum f.sp. *concoloris*	White fir	1,11
A. abietinum f.sp. *magnificae*	Red fir	2,4,7,8
A. americanum	Lodgepole pine	5
Annosus Root Disease		
Heterobasidium annosum	White/red fir	1,2,4.6-11
Cankers		
Cytospora abietis	White/red fir	2,4,5
Rusts		
White pine blister rust	Sugar pine	2,11
Cronartium ribicola	Western white pine	5
Yellow witches-broom *Melampsorella caryophyllacearum*	White fir	3,8
INSECTS		
Bark/Engraver Beetles		
Fir engraver beetle *Scolytus ventralis*	White/red fir	1,2,4-11
Mountain pine beetle	Lodgepole pine	3,8
Dendroctonus ponderosae	Sugar pine	1
Jeffrey pine beetle *D. jeffreyi*	Jeffrey pine	1,6,11
Woodborers		
Roundheaded fir borer *Tetropium abietis*	White/red fir	1,2,4-11
Flatheaded fir borer *Melanophila drummondi*	White/red fir	6,7
Defoliators		
Tent caterpillar *Malacasoma* sp.	Bitterbrush	4

VEG STRATA FOR NORTH SHORE PROJECT AREA

Figure 1. Locations of Pest Management Field Evaluation Sites, North Shore Project Area, July 18-20, 1995.



Appendix 1. Insect and Pathogen Biologies

Fir Engraver

The fir engraver (Scolytus ventralis) attacks both white and red fir in California. Trees ranging in size from large saplings to overmature sawtimber are susceptible. Attacks can cause patch-killing of cambium along the bole, top-kill, or tree death. Top-kill or death occur most often in firs that have been weakened by root disease, dwarf mistletoe, overstocking, soil compaction, sunscald, logging injury, or drought. The fir engraver also breeds in slash and windthrown trees.

The fir engraver usually completes its life cycle in one year, sometimes two. Adults fly and bore into trees or green fir slash from June to September; larvae, pupae, and adults over-winter under the bark. Pitch tubes are not formed as they are with pine bark beetles; the usual evidence of attack is boring dust in bark crevices along the trunk and pitch streamers on the mid and upper bole. Trees colonized early in the summer may begin to fade by early fall, but those colonized later in the year usually do not fade until the following spring or summer, often after the beetles have emerged.

Mountain Pine Beetle

The mountain pine beetle, Dendroctonus ponderosae, attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 4 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.

The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is the general rule, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine.

Attacks may extend from the root collar up to near the top. Pheromones released during a successful attack may attract enough beetles to result in a group kill. Pitch tubes and red boring dust in bark crevices or on the ground indicate successful attacks.

The adults bore long vertical egg galleries and lay eggs in niches along the sides of the gallery. A "J"-hook is common at the lower end of the gallery. The hatching 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.

The sapwood of successfully attacked trees soon becomes heavily bluestained. The bluestain fungi probably aid in overcoming the defenses of the host tree.

Natural factors affecting the abundance of the mountain pine beetle include low winter temperatures, 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 snd mortality increases. Relieving stress by thinning dense stands can prevent some group kills. Individual high value trees undergoing temporary reversible stress may be protected from attack by application of insecticide to the bole.

Jeffrey Pine Beetle

The Jeffrey pine beetle (JPB) is the principle bark beetle found attacking Jeffrey pine, Pinus jeffreyi, which is its only host. It is a native insect occurring throughout the range of Jeffrey pine from southwestern Oregon southward through California and western Nevada to northern Mexico. The beetle normally breeds in large, slow-growing, mature and/or stressed trees and under such conditions, mortality usually occurs as scattered, individual trees as opposed to large groups. Under outbreak conditons, often triggered by drought or other factors that weaken trees and predispose them to JPB attack, pines with diameters >6 inches DBH are attacked. Mortality under these conditons often occurs in large groups of from 30 to 100 or more trees. The JPB is not known to successfully breed in slash.

The JPB usually completes one generation per year in the northern part of its range but may complete two generations in the south. The adults generally fly and attack between late-May/early-June and early-October. The adults are cylindrical, reddish-brown to black, and are about 5/16 inch in length. Upon successfully attacking a Jeffrey pine, usually in the mid to lower bole, the adult JPB excavate a longitudinal egg gallery in the cambium/inner bark that often has a distinctive "J" shaped segment at the bottom. The eggs are laid in niches along the sides of the egg gallery which is packed with frass. After hatch, the larvae feed in mines perpendicular to the egg gallery and end in open, oval-shaped pupal cells in which pupation occurs. The JPB tends to overwinter as larvae and adults.

Jeffrey pine attacked by JPB can be identified by reddish pitch tubes on the bole where adults have attacked and/or brownish to reddish frass (boring dust) that collects in bark crevices and at the base of the tree. Attacked trees also exhibit a sequence of crown fade from greenish yellow to reddish brown. Frequently, crowns do not begin to fade until the spring of the year following attack.

Several other organisms are often associated with the attack of the Jeffrey pine beetle. Bluestain fungi, yeasts, and other fungi are transferred into the tree by the attacking adults. The California flatheaded borer, Melanophila californica, the pine engraver, Ips pini, and the emarginate ips, I. emarginatus, may be found in JPB attacked trees.

Red Fir Dwarf Mistletoe

Red fir dwarf mistletoe, Arceuthobium abietinum f. sp. magnificae, is a seed-bearing plant that parasitizes only red fir. It will not survive without

[illegible], and [illegible], [illegible] and bough [illegible]
[illegible] especially by the beetle increases [illegible]
[illegible] (Dendroctonus [illegible]) [illegible] of [illegible]
[illegible]
[illegible] killing. [illegible] will [illegible] come [illegible]
[illegible] pheromones [illegible] attacks [illegible]

[illegible]

[illegible] TB usually completes [illegible] generation per year in [illegible] but may [illegible] two [illegible] the [illegible] attack between late-May/early-June and early [illegible] long, reddish brown to black, and are about 1/8 inch long. [illegible] carefully excavating a [illegible] egg gallery, usually [illegible] the [illegible] excavate a longitudinal egg gallery in the cambium [illegible] use a [illegible] "J"-shaped segment [illegible] the bottom, [illegible] along the [illegible] of the egg gallery which [illegible] larvae [illegible] the larvae feed in winding [illegible] oval-shaped pupal cells in which pupation occurs. [illegible] emerge as [illegible] adults.

[illegible] pine attacked by [illegible] can be identified by reddish pitch tubes [illegible] whose [illegible] have [illegible] and/or [illegible] bark crevices and at the base of the tree. [illegible] a sequence of crown fade from greenish yellow to reddish brown [illegible] do not begin to fade until [illegible] overwintering [illegible]

[illegible] other organisms are often associated with [illegible] attack of the [illegible] fungi [illegible] and other fungi [illegible] attacking [illegible]. The California fivespined ips [illegible] and the [illegible] is found in [illegible]

[illegible] It will not survive winters [illegible] living host tissue, which it depends on for support, food, nutrients, and water.

Dwarf mistletoes initiate their life cycle when a seed lands on a needle or small twig of a host. The seed is coated with viscin, a sticky substance that allows it to adhere to the host tissue. During rains, the viscin becomes mucilaginous, allowing the seed to slide down to the needle base where it may lodge. The seed germinates in the winter or spring and the radicle grows along the twig until it reaches a needle base or bark irregularity. The radicle forms a holdfast and penetrates the twig into the xylem. A type of root system then develops in the twig. In 3 to 5 years from seed deposition, most successful infections will appear as branch swellings and will bear mistletoe shoots. These shoots will not produce fruit until at least 5 years following seed deposition, the average being 8-9 years. Fruit mature in the fall and disseminate seed in September and October. The seeds are explosively discharged from the fruit through the buildup of turgor pressure. Seeds normally have an upward trajectory.

Red fir dwarf mistletoe does not spread rapidly following establishment. Vertical spread in a tree averages less than 3 inches per year. Horizontal spread in a stand <u>without overstory infection</u> is also quite limited. The dense foliage of red fir limits spread because of the high probability of interception of the seed. Spread from infected overstory to understory may be up to about 100 feet, but it is usually less; the actual distance is dependent on slope, wind, and other factors. Trees less than 3 feet tall have a very limited chance of infection because of their small target size.

The effects of this mistletoe on true fir growth and mortality relative to the Hawksworth 6-Class rating system are shown below. Source: Hawksworth, F.G., et. al., 1992. Interim dwarf mistletoe impact modeling system - users guide and reference manual. USDA Forest Service, Forest Pest Manangement, Methods Application Group, Fort Collins, CO, Report MAG-91-3, 90p.

	HAWKSWORTH DWARF MISTLETOE RATING						
	0	1	2	3	4	5	6
10-YEAR GROWTH LOSS (%):	0	0	0	2	5	30	50
10-YEAR MORTALITY (%):	0.0	0.7	2.3	5.0	8.8	13.5	19.2

Annosus Root Disease In True Fir

Heterobasidion annosum (formerly *Fomes annosus*) is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone 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 the National Forests

in California, with incidence particularly high on true fir in northern California campgrounds. Incidence is somewhat higher in older, larger fir stands and in stands with high basal areas (over about 330 square feet/acre).

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 begin by aerial spread of spores produced by the conks and subsequent colonization of freshly cut stump surfaces or wounds on living trees. The fungus then spreads through root contacts into the root systems of adjacent live true fir. Local spread of the fungus from a stump typically results in the formation of a disease center, with dead trees in the center and fading trees on the margin. These centers usually continue to enlarge until they reach natural barriers such as stand openings or non-susceptible plants.

In pines, H. annosum grows through root cambial tissue to the root crown where it girdles and kills the trees. In less resinous species such as true firs, the fungus sometimes kills trees, but more frequently it is confined to the heartwood and inner sapwood of the larger roots where it causes a chronic butt and root decay and growth loss. Thus, while infection in true fir usually does not kill the host, it does affect its growth and thriftiness. Losses in true fir from H. annosum are mainly the result of windthrow because of root decay, and reduced root systems that predispose trees to attack and eventual death by the fir engraver beetle. Field observations suggest that vigorous young firs are usually able to regenerate root tissues faster than they are lost to the root disease. But when true firs slow in growth because of stand and/or site conditions, root development decreases to where there is a net loss in roots and the trees slowly decline due to the gradual loss of their root systems. This decline may take 10 to 20 years before tree death occurs.

There are two pathogenic strains of the fungus that differ in their ability to infect various conifers in California. The "P" or pine type infects and kills all pines (although susceptibility of pine species vary), in addition to incense-cedar and western juniper. The "S" or fir type infects true fir, Douglas fir and giant sequoia. Knowing which type is active in a stand is important, and will allow favoring alternate conifer species because the fungus strains do not cross infect between the two groups listed above.

Cytospora Canker

Cytospora abietis is a canker-causing fungus that infects true firs throughout their range in California. It is a weak parasite, and usually attacks trees that have been weakened by disease, drought, fire, insects, or human disturbance. It is most commonly associated with dwarf mistletoe infection, and sometimes attacks as many as a quarter of the mistletoe-bearing branches, killing many each year. The bright red flags of recently-killed branches on dwarf mistletoe-infected red firs are almost always the result of lethal Cytospora infections. C. abietis occasionally reaches especially damaging proportions in certain years, and

may attack trees of any age, sometimes killing the tops or all of young trees.

White Pine Blister Rust

Blister rust (Cronartium ribicola) is caused by an obligate parasite that attacks sugar and western white 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 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 pine 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 (these are called **lethal** cankers). Bole cankers result in girdling and death of the tree above the canker. Cankers whose closest margins are more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result (these are called **non-lethal** cankers).

Environmental conditions are critical for successful infection and limit the disease in most years. Moisture and low temperatures favor infection of both hosts, and must coincide with spore dispersal for infection to occur. In California, these conditions occur only infrequently, usually in cool moist sites such as stream bottoms or around meadows. In so called "wave years" when favorable conditions occur, high levels of infection can result. Wave years in California have occurred at approximately ten-year intervals in the past. As one moves from sites most favorable for rust to less favorable sites, the frequency of wave years decreases.