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2007 Situation Summary

RED FIR DECLINE AND MORTALITY ON THE STANISLAUS NATIONAL FOREST

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Abstract

The mortality of red fir in the higher elevation forests of the Calaveras Ranger District, Stanislaus National Forest has generated a considerable amount of concern and interest. Ground surveys were conducted in 2006 in several areas on the district to assess insect and disease presence. The purpose of the surveys and following report were to identify damage agents and stand conditions that may be causing the decline. It is the opinion of the authors that, chronic dwarf mistletoe infections predisposed the stands to decline and, an ongoing drought combined with *Cytospora* infections to trigger the decline. Ultimately, the fir engraver, flatheaded fir borer and possibly root rot fungi were the agents that caused the mortality. The fir decline and mortality is seen as being a complex involving at least 5 major components and is best explained by Manion's "Decline Spiral" model. General management alternatives are outlined for consideration.

Since 2003, mortality of red fir in the northern districts of the Stanislaus National Forest has become more pronounced and noticeable. Discussions with forest leadership, district personnel, local private industry, and Forest Health Protection have been held to assess this issue. Many questioned if this mortality was a continuing problem or a cyclic event. This report summarizes the current conditions of the general forest on the Calaveras and Summit Ranger Districts where most of the mortality has been detected, identifies insects and pathogens present, and discusses management alternatives that could be developed to mitigate the damage.

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<u>Surveys</u>
During the summer of 2006, using 2004 and 2005 FHP aerial survey maps (*see* Appendix A), several large polygons were ground checked on the district delineated with mortality. Transects were run through areas in attempts to thoroughly capture stand attributes in which damage was occurring. Tree information on species, condition, diameter, probable year and cause of death were collected. Although red fir dwarf mistletoe does not generally induce brooms (Scharpf, 1964) many were observed (see figure 1). While trees were not Hawksworth-rated for dwarf mistletoe infection levels, observations of stands revealed moderate to severe infections at most locations. All locations visited were above 6000 feet in elevation, and predominantly composed of mature red fir. The average plot diameter-at-breast height ranged from 16 to 38 inches, with overall average of 24 inches; and basal areas varied between 180-250 square feet/acre.

<u>Stand Composition</u>
With the exception of a few plots, most of the live and dead basal area, and species composition was composed of large-diameter red fir. Dead red firs were usually the largest trees in the plots, remaining as standing snags. Recent mortality of red fir was low – about one per plot, but older dead (longer than 2 years dead, including snags) were nearly a quarter of the standing stems. Because of the low stem density per plot, the loss of one mature tree altered stand structure significantly. Three plots were mostly comprised of large-diameter lodgepole pine – one around Bear Valley Ski area, and two east of Sherman Acres. At the Tuolumne State Game Refuge, plots were predominantly large-diameter white fir with minor red fir component.

Ground observations were consistent with the FHP aerial detection maps 2002 to 2006 (*See* Appendix A). Starting in 2002, aerial surveyors detected very small areas of mortality (1 to 5 trees per acre) in the Calaveras and Summit Ranger Districts. By 2004, true fir damage was visible and widespread in both districts – most of which was *Cytospora* visible in tree crowns. In 2005, the largest mapped areas with mortality were north and south of the Stanislaus River, by Big Meadow Campground on the Calaveras. Less damage was detected in 2006, again around and south of Bear Valley in the Calaveras RD.

INSECT/DISEASE AGENTS

Several damage agents were observed at all locations. Dwarf mistletoe infections were moderate to severe in most locations, indicating that infections have been present for a long time. The insects most often detected on recently dead firs were Flatheaded fir borer or fir engraver. Assessments of dead and live trees revealed that these agents are working as complexes that ultimately lead to tree decline. Much of the mortality observed was not the result of one damaging agent. (*See* Appendix B *for complete insect and disease biology*).

<u>Dwarf mistletoe</u> (*Arceuthobium abietinum f.sp. magnificae*) was the most prevalent damage agent observed on red fir.. Witches' brooms were found in several large trees, indicating very old infections (*see* Figure 1). When trees are heavily infected, dwarf mistletoe will reduce diameter and height growth, ultimately resulting in mortality. Infections perpetuate when measures are not taken to mitigate spread or intensity of the disease. The parasitic nature of dwarf mistletoe is known to increase moisture stress and predispose hosts to attacks by fir engraver (Ferrell 1974, Berryman and Ferrell 1988) or pathogens – particularly *Cytospora abietis*.

Figure 1. Dwarf mistletoe broom in red fir (far right), leading to potential terminal breakage; Bear Valley Ski Area, Calaveras Ranger District.

Cytospora canker *(Cytospora abietis)* is a weak parasite that commonly attacks branches already infected by dwarf mistletoe. This canker-causing fungus can kill young trees or treetops, while only branches are killed on larger hosts (Scharpf 1993). This pathogen is a normal component of true fir ecosystems. At certain locations on the Stanislaus National Forest, dwarf mistletoe and *C. abietis* infection in red fir is severe (*see* Figure 2). Dead branches are potential hazards for drivers and recreationists that frequent these areas. *Cytospora* infection levels at surveyed areas were moderate to severe, due in large part to the high levels of dwarf mistletoe already present. However, these infection levels were relatively low until about 2004, when there appeared to be a rapid increase of the pathogen throughout the crowns.

While the published literature frequently refers to *Cytospora abiets* as a weak pathogen (Wood *et al*, 2003) it is never the less both a ubiquitous and a very successful pathogen. *C. abietis* owes its success to the presence of the fir dwarf mistletoe. The dwarf mistletoe haustoria induce swellings on fir branches and these in turn provide the entry courts for the germinating *Cytospora* spores. The parasitic mistletoes deprive the branches of resources and allow the weak pathogen, *Cytospora*, to become established. Once established, the fungus causes cankers which lead to flagging and branch death. Like many weak pathogens the *Cytospora* ensures its survival by being a prolific producer of spores.

Fir engraver (*Scolytus ventralis*) was the primary bark beetle found infesting the red and white firs on survey plots. Fir engraver attacks can be found scattered across the landscape, since they select hosts that are typically under severe stress due to lack of moisture or other debilitating condition. Outbreaks of fir engraver usually occur after periods of drought (Furniss and Carolin, 1992). Based on risk-rating systems for red and white firs in Northern California, trees with ragged crowns and low live crown percentages are at highest risk for attack (Ferrell 1980). Primary causes of poor crown conditions were frequently attributed to prior dwarf mistletoe and

Cytospora infection. Top-kill and terminal breakage by fir engraver subsequently creates hazardous situations, especially during heavy windstorms or wildfires.

Figure 2. *Cytospora* infection on red fir, evidenced by red flagging; Aspen Meadow, Summit Ranger District.

<u>Flatheaded fir borer</u> (*Phaenops drummondi*) was found to a lesser degree on dead trees and again, in combination with, heavy dwarf mistletoe, *Cytospora* infection, and fir engraver activity on trees.

In discussion with the service area pathologist (John Pronos, retired, *personal communication*), the probability of annosum root disease is high in true fir areas that were historically logged or frequently disturbed. True firs are more vulnerable to infection than pines and some of the past tree decline occurring in the northern Stanislaus was found to have been associated with root disease presence.

DISCUSSION

Preliminary ground surveys and recent aerial detection reports find that much of the red fir deterioration in the Calaveras and Summit Ranger Districts was due to a number of interacting stressors, which include but is not limited to: old age, stand structure, dwarf mistletoe, the fir engraver, the fir flatheaded borer, Cytpospora canker, and a prolonged drought. The decline model / concept that best explains what we observed on the Stanislaus is the "Decline–Disease Spiral, proposed by professor Paul Manion (1991) The Manion Spiral (Figure 3) suggests that a tree species can go into a decline spiral if one representative of each of three sets of stressors is acting upon the species. It was Sinclair (1965) who first divided stressors into 3 categories; **predisposing factors** (i), **inciting factors** (ii) and, **contributing factors** (iii). The decline spiral predicts that a species can go into decline if there is first a factor that will predispose the tree to a decline, followed by an inciting factor to trigger the decline and, finally a contributing factor that could eventually kill the tree. While the model predicts that a tree can go into decline with only one factor from each of the 3 sets is acting upon the tree, in most documented decline examples there have been several factors from each of the sets acting upon the declining trees.

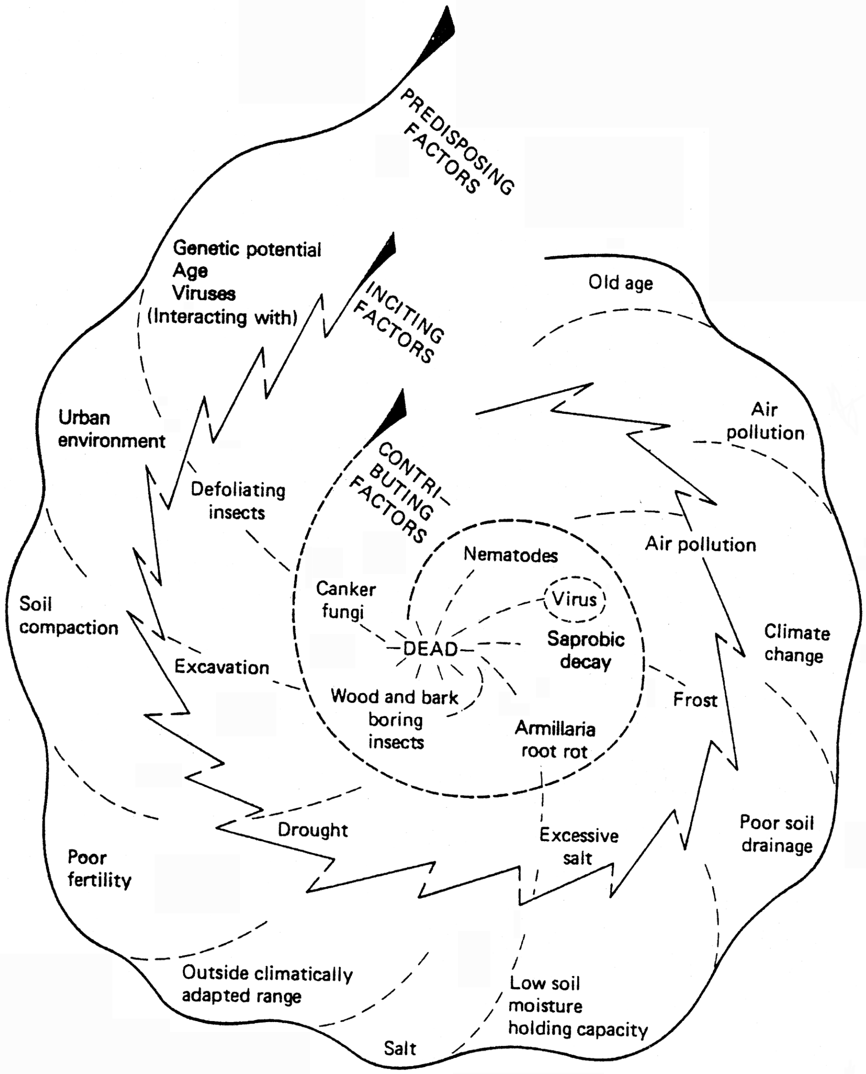

Figure 3. The Manion Decline Spiral, showing the 3 sets of stressors and most of the factors that could play a role in the complex that makes up an individual tree species decline.

The corollary to the Manion Decline Spiral (which is not often cited) is that should one of the sets of factors be mitigated early enough then the spiral should unwind and the tree should recover.

For the purposes of evaluating red fir decline the relevant stressors thought to be active on the on the Stanislaus National Forest have been tabulated below.

(I) Predisposing factors	(II) Inciting factors	(III) Contributing factors
Dwarf mistletoe	Drought	Flatheaded borer
Stand structure	Cytospora canker	Fir Engraver
Tree age	defoliating insects	Anossus root rot
Climate change		other bark beetles
		etc.

Table 1. The stressors acting upon red fir on the Calaveras and Summit Ranger Districts of the Stanislaus National Forest tabulated in into the Sinclair Classes as used in the Manion Decline Spiral model, with the 5 major stressors highlight in yellow.

Following the above Manion model, the dwarf mistletoe infections are viewed as being the predisposing factor, the drought and *Cytospora* infections were the inciting factors that triggered the accelerated development of damage polygons and the contributing factors that lead to tree death are viewed as being the insects and possibly the root rot fungi.

Tree mortality is a natural part of a healthy forest! As professor Manion has often said ***"There is a healthy amount of disease in a healthy forest!"*** The decline spiral can only be invoked when there is a mortality level that is significantly above historic or background levels. Both Manion and Sinclair made their decline observations while working with native insects or fungi and thus, their concepts do not apply to the past epidemics of exotic diseases such as, chestnut blight and Dutch elm disease, or for that matter what the exotic emerald ash borer is currently doing to the ash resource of Michigan and Ohio (**Poland T. M., & D. G. McCullough, 2006).** In the Manion quote, ***"There is a healthy amount of disease in a healthy forest!"*** the word "***disease"*** should be replaced with the word ***"death"***, for insects can kill trees as easily as fungi.

<u>Management Strategies suggested by the Decline Spiral Model.</u>

The contributing factors in this decline are all native, and thus a natural part of the forest make up. As the insects are not at outbreak population levels, actions aimed at them will produce minimal (if any) gain. As droughts are both unpredictable and uncontrollable there is no management strategy available for this decline trigger. As, the pathogen, *Cytospora* is ubiquitous direct control (by spraying) is not practicable. Having eliminated the inciting and contributing factors we are left with the predisposing factor, the mistletoe. If we can manipulate the mistletoe so that the stands are no longer predisposed to a decline spiral, then the return of local drought or wet conditions favoring *Cytospora* sporulation will not lead to either a build up of the contributing factors or a decline spiral. This is not to say that some trees will not continue to die. The oldest and most vulnerable (stressed) will continue to die, but the mortality will be at acceptable or natural levels. These are the levels of mortality found in a healthy stand.

Other management Strategies. No Action

If stand conditions in red fir infected areas are not altered from their current state, insect and disease associated injury will continue and possibly even increase. Eventual mortality, branch dieback, and top-kill of red fir caused by a combination of, dwarf mistletoe, *Cytospora,* wood boring and bark beetles can be expected. Some understory regeneration may die from mistletoe and *Cytospora* infections and those that do survive will become infection sources as they develop. Uneven aged stands will not outgrow existing dwarf mistletoe infections as the mistletoe is continually cycled in all age classes. As infection intensifies, host growth is reduced, and both the number of *Cytospora* infection courts and susceptibility to bark beetles increases. Mortality levels may fluctuate from year to year, but over time will be higher than normal. During periods of drought, heavily infected trees will be unable to withstand the additional stress and succumb.

A 'hands-off' approach toward infected red fir stands has multiple effects besides tree loss. Seed sources in the form of overstory trees are eventually be lost from prolonged mistletoe infection or insect attack. The build-up of dead trees – standing or downed – create dangerous fuel conditions in the event of wildfire. Such high fuel loads typically result in stand-replacing fires that completely destroy all vegetation and may require intensive management to recover. The loss of private property adjacent to Forest Service lands should be considered in areas where infected red fir trees are at risk.

While dwarf mistletoe infections and bark beetle associated mortality are typically viewed as losses, they can be indirectly beneficial to other components of the ecosystem. From a wildlife management standpoint, the effects of mortality agents in a stand can be positive. Snags, downed woody material, and dead tops created by insects and pathogens may be desirable. Bark beetles and mistletoe help create openings in the stand that benefit wildlife and increase structural and species diversity. Bark beetles, dwarf and leafy mistletoe plants and fruits are common food sources for other insects, birds, and mammals. Witches' brooms may provide cover and nesting sites for many wildlife species.

Management Treatment Options and Considerations

While several factors have been presented as causes for decline, the only manageable factors are stand structure and dwarf mistletoe. Fir engraver and flatheaded fir borer populations are currently not at outbreak levels, and thus suppression activities at this time would produce minimal gain in stand health. Prevention of *Cytospora* infection is also unfeasible as spores are wind disseminated. Climate change towards warmer summer temperatures and less winter precipitation could result in sustained droughts, but also cannot be controlled nor accurately predicted. Therefore, dwarf mistletoe management should be the focus of planning efforts for improving overall forest health. Changes in stand structure will result as dwarf mistletoe mitigation is implemented. These options can easily be integrated to support other resource objectives as well.

Depending on the current state of the stand, rigorous treatments may be necessary to bring stands to a manageable level. "Manageable" levels of DM equals a low mistletoe incidence and negligible growth losses.

Under the category of Old Forest Ecosystems in the Sierra Nevada Forest Plan (2004), tree removal is restricted above 25 inches or that 40% basal area of the largest trees will be retained, except in the case of fuel treatments. The irony is that many of the largest trees had the highest ratings of infection in the stands surveyed on the Stanislaus National Forest. Surveys found that while overall stand average was 24 inches DBH, red fir the major overstory averaged 31 inches DBH. Some firs were as large as 49 inches in diameter with few stems per acre. Despite good intentions of the SNFP, the regulations constrain efforts to develop healthy old-growth stands. Leaving infected large diameter trees will only perpetuate the cycle of infection that results in premature mortality, in all age classes, from the combined effect of insects and pathogens. While it might be too late to do much for the, older, chronically mistletoe infected, larger trees, it is not too late to do something for the maturing trees. If the stand can be manipulated so that the currently, mistletoe-free, cohort of maturing trees reaches maturity still mistletoe-free they will be healthier and live longer to provide us with the large tree –old growth- stand characteristics we desire. To obtain future gains in forest health we are suggesting that a sacrifice should be made now and, that a small number of, larger diameter, chronically mistletoe infested, trees be removed now before they spread disease to our future old growth trees.

The ultimate goal of treatments should be to minimize both infection spread and intensification of dwarf mistletoe (Parmeter 1978). Outlined are treatments that require whole tree removal, tree/stand manipulation, or complete clearing to create buffer strips. Mistletoe infection levels at particular locations may necessitate removal of large trees to prevent re-infection of the understory. Following are management treatment options suggested for use to treat dwarf mistletoe-infected red fir stands.

Direct

1. **Broom Pruning**

   Objective: To extend tree life and maintain individual treated trees on a site as long as possible.

   Guidelines: Remove dwarf mistletoe witches' brooms from high-value trees only if they will have at least 30% live crown after removal of the brooms. This treatment will not eliminate mistletoe from the stand, nor will it prevent future spread. It is most often used in areas that have little or no understory.

2. **Tree Removal**

   Objective: To remove trees expected to die within ten to fifteen years, to prevent build-up of bark beetles, and to reduce dwarf mistletoe in the stand.

   Guidelines: Identify and remove trees with a Dwarf Mistletoe Rating[1] (DMR) of 5 or 6, or a rating of 4 with mistletoe in the upper one-third of the crown. Such trees are generally not prunable, pose a threat to adjacent uninfected hosts, and have a higher probability of dying within 10-15 years or during the next drought. It is advisable to remove infected firs that will have less than 30 percent live crown after pruning, or are growing in dense aggregations where removal of selected individuals would benefit neighboring uninfected or slightly infected firs.

[1] Hawksworth, F.G. 1977. The 6-class mistletoe rating system. General Technical Report RM-48. Rocky Mountain Forest Range and Experiment Station, Fort Collins, CO. 7 pg.

Remove all trees having bole infections at a point less than six inches in diameter. Bole infections are not serious from the standpoint of spreading mistletoe, but they deform and/or lead to mortality of small trees and failure of large trees.

3. **Creation of Buffer Strips**

   Objective: To limit or stop the spread of dwarf mistletoe into a treated area from adjacent infested areas.

   Guidelines: Use host-free strips to prevent mistletoe from re-entering the control area or where the parasite is not eliminated, from leaving the site. Buffer strips should be at least as wide as the height of the highest mistletoe plants in the adjacent infested stand. Examples of existing buffers include meadows, roads, rivers, clearings, and aggregations or plantings of non-host trees. Construction of new roads, structures, or campsites can also be used to create buffer zones and eliminate pockets of heavily infected trees.

4. **Branch Pruning/Eradication**

   Objective: To reduce or eliminate dwarf mistletoe seed in the stand and improve tree vigor.

   Guidelines: For trees with DMR of 3 or less, or a rating of 4 and no mistletoe in the upper one-third of the crown, prune all lower branches, both healthy and diseased, at the bole up to including the second whorl of branches above the highest visible mistletoe infection. Experience has shown that despite removing branches up through the highest infection or even one more whorl, latent infections almost certainly appear in three to five years. Whenever possible, avoid removing more than 50% of a tree's live crown. Pruning of all infected branches in infected trees in an attempt to eradicate this pest requires careful adherence to these guidelines, and will have the greatest chance of success when used on isolated high-value trees or in areas of one acre or less where infection is light. Do not attempt eradication if the pruning will result in a tree with a crown of less than 30%, or if the tree will be exposed to continued infection from adjacent infected trees. It is difficult to completely eliminate dwarf mistletoe from a tree without at least two treatments. Plan to reenter if needed at least twice after the first entry.

Indirect

1. **Thinning**

   Objective: To improve stand growth and tree vigor.

   Rationale: Despite direct dwarf mistletoe treatment, the benefits from reducing or eliminating infection may be offset by continuing competition for growing space in overcrowded stands. When stands are overstocked, mistletoe vertical spread is increased due to crown thinning and reduced height growth (Parmeter 1978). Even where mistletoe is absent, overstocking contributes to poor tree vigor and unnecessarily high risk of death from bark beetle attack. Although privacy and esthetic requirements in campgrounds may prevent thinning to stocking levels optimum for timber-producing forests, some thinning may be necessary if campground stands are to maintain vigor and resistant to pest attack.

2. **Favoring and Planting Non-hosts Conifers and hardwoods**

   Objective: To eventually replace infected trees with uninfected trees and to lessen future spread of dwarf mistletoe.

   Rationale: Because true fir dwarf mistletoe infects neither pines or hardwoods, managers may favor these non-hosts so that they become a larger component of the stand. Selected individuals or small aggregations of these non-host species may be retained as buffers to movement of the parasite, or as eventual replacements for severely infected firs that cannot be removed during mistletoe treatment. Wherever there are pure stands of severely infected hosts, planting of non-susceptible species may be the only way to ensure that new trees replace the firs that die or are removed.

Direct suppression efforts to control fir engraver or flatheaded fir borer are not advisable if the residual stand is still susceptible to attack. Resurgence can occur if treatments do not address improving overall stand condition. Management actions that target other resource objectives such as fuel reduction or wildlife habitat preservation in these red fir communities can incorporate strategies that also attend to insect and disease issues.

Some management options may not feasible due to size of treatment areas, funding, accessibility, etc., but proper application of treatments in strategically placed or high priority areas would still be valuable in improving current stand conditions. Pruning of mistletoe-infected branches are effective in rejuvenating tree vigor while reducing the spread of infection onto regenerating understory. If there is no susceptible understory to protect, low dwarf mistletoe infections in the overstory can be tolerated. Whole tree removal of highly infected individuals would also be a step towards long-term prevention. If management is considered, procedures must be properly implemented to not further aggravate or promote subsequent insect/disease infection, repeated treatments may be necessary. Complete eradication of dwarf mistletoe would not be practical or feasible at these levels of infection. At a minimum, dwarf mistletoe infections should be used as a factor in identifying trees that should be removed eventually. The best approach would be to eliminate or reduce dwarf mistletoe to insignificant levels since stands can tolerate low infection ratings and continue to be very productive.

Growth and Mortality Data: The tables below show how dwarf mistletoe affect true firs. This data is taken from Hawksworth, F.G. et al., "Interim dwarf mistletoe impact modeling system: User's guide and reference manual." USDA Forest Service, Methods Application Group, Fort Collins, CO. Report MAG-91-3, March 1992. 90 pg.

Table 1. Relationship of True fir Diameter growth potential to Dwarf Mistletoe Rating (DMR)

DMR	**0**	**1**	**2**	**3**	**4**	**5**	**6**
10-year diameter growth potential (%)	100	100	100	98	95	70	50

Table 2. True Fir 10-Year Mortality Percentages

DMR	0	1	2	3	4	5	6
% mortality, small trees (DBH < 9 inches)	0.0	0.8	2.8	6.1	10.5	16.2	23.1
% mortality, large trees (DBH > 9 inches)	0.0	0.7	2.3	5.0	8.8	13.5	19.2

While the survey locations presented here are but a small percentage of the Forest where red fir occurs, they represent areas of sizable and significant value and use. Protection of these areas and others should concern more than just local forest managers and immediate community residents. More surveys of red fir forests in the Stanislaus are planned in the upcoming years. If you have any questions or require more information, please do not hesitate to contact our field office.

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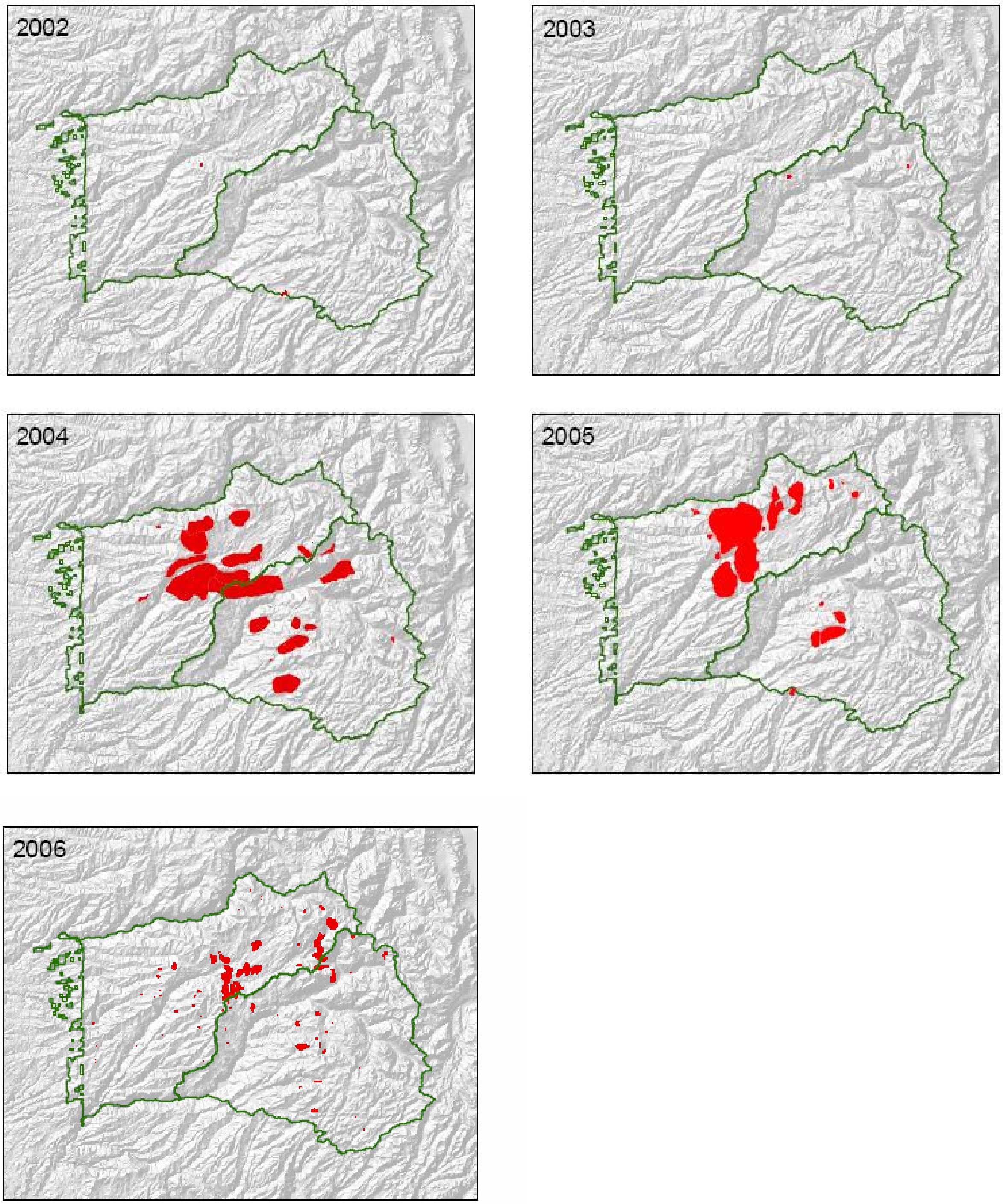
Appendix A. 2002-2006 Forest Health Protection Aerial Detection Surveys of True Fir in the Calaveras and Summit Ranger Districts, Stanislaus National Forest.



Appendix B: Insect and Disease Biology

Dwarf mistletoe (*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. True Fir dwarf mistletoe (*Arceuthobium abietinum*) infects principally red fir (*Arceuthobium abietinum f.sp. magnificae)* and white fir (*Arceuthobium abietinum f.sp.abietinum*).

Dwarf mistletoe 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, 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 20-60 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 are occasionally vectored by birds and animals. Vertical spread of mistletoe within true fir crowns is normally limited to less than one foot per year because of foliage density.

Dwarf mistletoe 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.

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.

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 cambium along the bole, top-kill, or tree death. Top-kill or death occur most often in the 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, adults overwinter 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 beetles have emerged.