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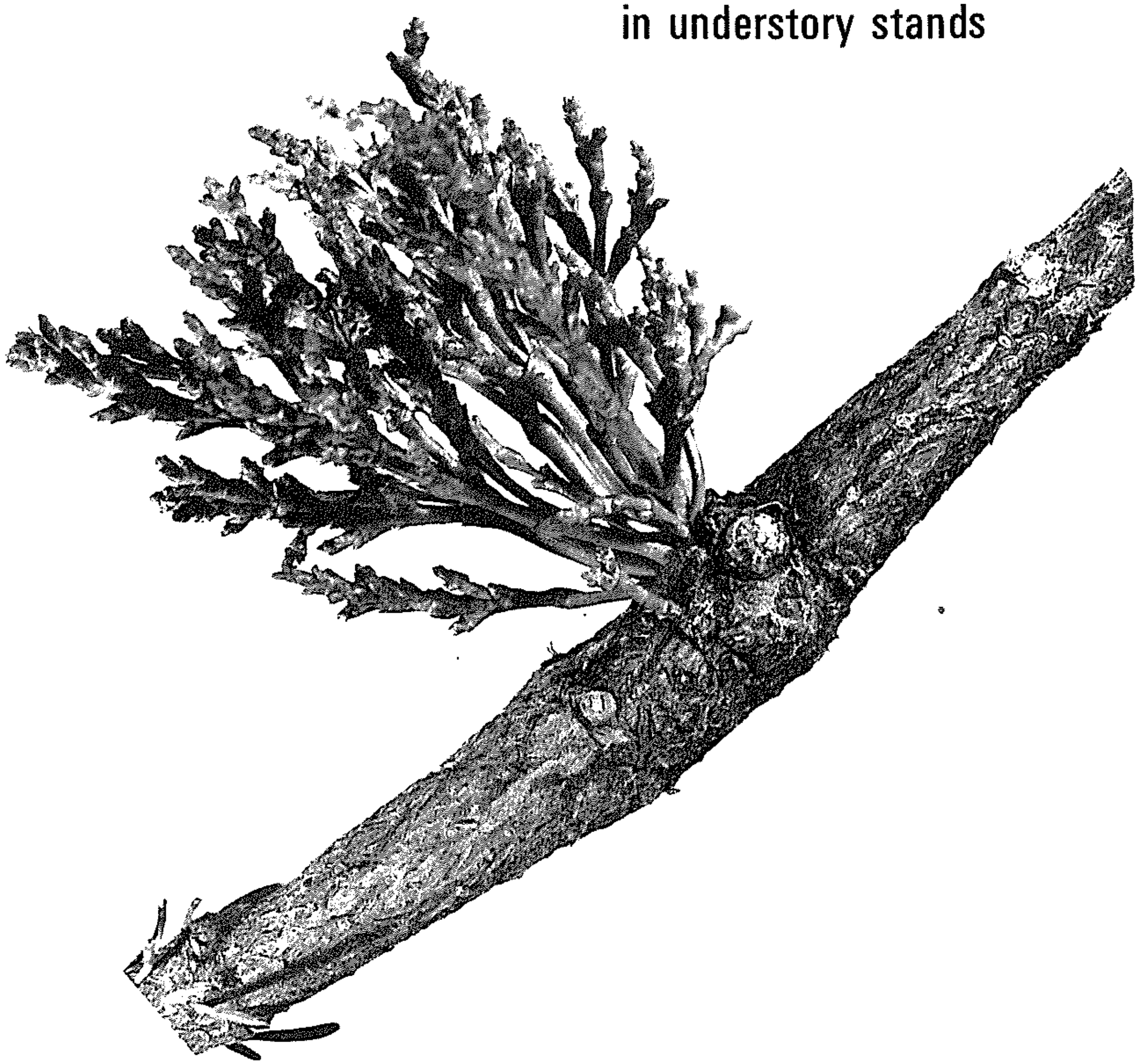
FOREST SERVICE
U.S.DEPARTMENT OF AGRICULTURE
P.O. BOX 245, BERKELEY, CALIFORNIA 94701

DWARF MISTLETOE ON RED FIR....
infection and control in understory stands



U.S.D.A. FOREST SERVICE RESEARCH PAPER PSW-50 1969

Scharpf, Robert F.

1969. **Dwarf Mistletoe on Red Fir . . . infection and control in understory stands.** Berkeley, Calif., Pacific SW. Forest and Range Exp. Sta. 8 p. illus. (U.S.D.A. Forest Serv. Res. Paper PSW-50)

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Oxford: 176.1 *Arceuthobium campylopodum*—413[174.7 *Abies magnifica*—442.1].

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Dwarf Mistletoe On Red Fir . . .
infection and control in understory stands

ROBERT F. SCHARPF

Contents

The Author

ROBERT F. SCHARPF, a plant pathologist, is studying problems in forest diseases and their control. Native of St. Louis, Mo., he earned a forestry degree (1954) at the University of Missouri. He also holds a master's degree in forestry (1957) and a doctorate in plant pathology (1963) from the University of California, Berkeley. He joined the Forest Service in 1960, and has been with the Station's Berkeley research staff since then.

Red fir (*Abies magnifica* A. Murr.) composes about 10 percent of the total net volume of live sawtimber in California's commercial forest land (Calif. Forest & Range Exp. Sta. 1954). For the most part, this species grows as pure stands at high elevation. Its range extends from the southern Cascade Range of Oregon through California's northern Coast Range and Sierra Nevada. Forest managers did not begin logging red fir in appreciable volume until the late 1940's because of its relative inaccessibility.

A producer of wood of good quality, red fir is destined to grow in economic value (Hallin 1957). The species is also valuable in many forested areas used for recreation purposes. It helps regulate the melt of the snowpack in the high mountains of California (Anderson 1963). And when properly managed and harvested, it is sought after as a Christmas tree crop.

Because of the increasing value of red fir stands, forest managers are concerned about any hazards to the species. The continued demand for timber products, recreation, water, and other benefits derived from multiple-use forests requires an increased effort in managing red fir stands.

Among the most serious parasites of conifers in western North America is the dwarf mistletoe (genus *Arceuthobium*). Offord (1961) estimated that about 200 million board feet are lost annually from the effects of this parasitic plant in California's forests. Throughout the State, dwarf mistletoe is wide-spread and severe in red fir stands (California Forest Pest Control Action Council 1968). In a survey, about 45 percent of random plots examined held infected trees. And on the average, about 35 percent of the trees on these plots were infected. Therefore, losses in red fir alone amount to a large percentage of the total loss of timber from the effects of dwarf mistletoe.

The dwarf mistletoe that attacks red fir is *Arceuthobium campylopodum* Engelm. *f. abietinum* (Engelm.) Gill. It is identical morphologically to the species that attacks and infects white fir (*A. concolor* [Gord. and Glend.] Lindl.) and resembles dwarf mistletoes on other conifer species. But it is host specific—it infects only red fir (Parmeter and Scharpf 1963).

This paper reports a study of dwarf mistletoe on understory red fir growing in association with heavily infected overstory trees. It relates height and age of trees to both frequency and intensity of infection on study plots set up on four National Forests in California. And it suggests how the spread of and damage from this parasite in residual or newly established red fir stands might be reduced by applying silvicultural control.

The Parasite

Dwarf mistletoes spread by means of an explosive fruit mechanism. They cast their seeds for a maximum vertical distance of 15 feet and a horizontal distance of up to about 40 feet (Hawksworth 1959). Aided by wind, however, seeds discharged from plants in the tops of old-growth firs may spread to surrounding smaller trees for a distance of 100 feet—and probably sometimes even farther. The target area a tree presents has been recognized as a factor that influences infection of conifers by dwarf mistletoes (Childs 1963; Hawksworth 1958; Scharpf 1968; Wicker and Shaw 1967). And how long a tree is exposed to infection is also considered critical to infection (Childs 1963; Wicker and Shaw 1967). Either or both factors may be responsible for infection of red fir by dwarf mistletoe.

In general, the parasite spreads through a stand at a relatively slow rate. Hawksworth (1961) reported that dwarf mistletoe in young ponderosa pine stands in the Southwest spreads laterally about 1 to 2 feet a year. Thus, once dwarf mistletoe has been eliminated from an area reinvasion takes place very slowly. In spite of their slow rate of spread, dwarf mistletoes are a serious parasite of conifers in the West.

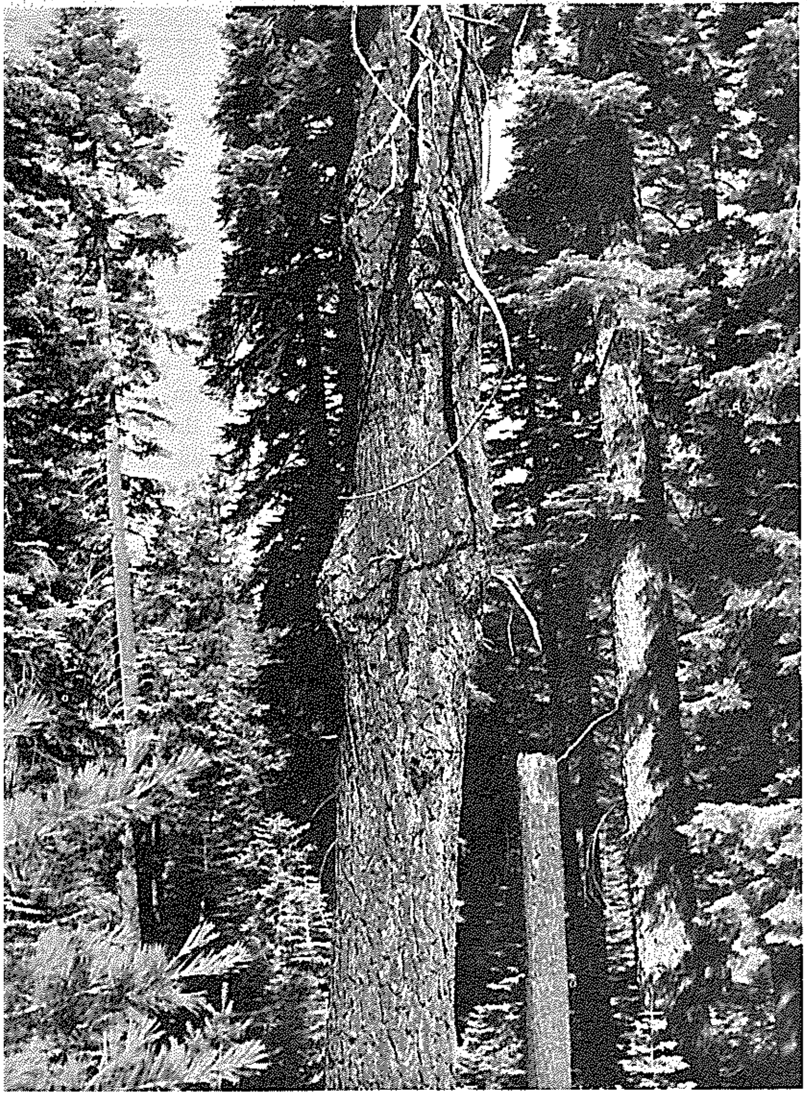
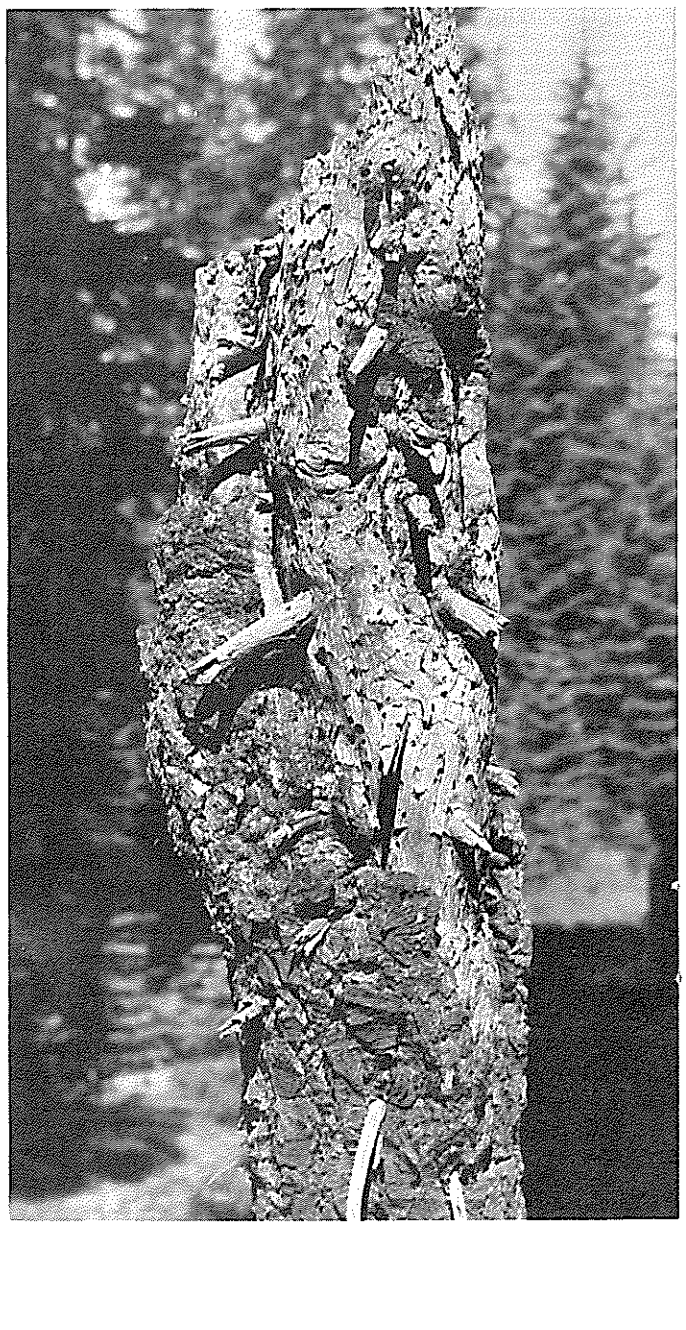


Figure 1.—*Bole swellings from dwarf mistletoe on red fir reduce timber quality and often make a tree nonmerchantable.*

Figure 2.—*Old dwarf mistletoe bole swellings on red fir may become insect riddled and decayed. Trees in this condition often break off as a result of the decay.*



This parasite damages firs in several ways. Badly infected trees, particularly suppressed understory trees, are deformed, killed, or weakened to the point that they succumb to insect attack. The larger heavily infected trees, although not often killed, have markedly reduced growth rates. Infections cause bole swellings on the main stem *(fig. 1)*. These bole swellings provide an opening for decay fungi and often make the tree unsuitable for harvest. Also trees with decayed bole swellings often break off at the swelling, endangering visitors and property on campgrounds and other recreational sites *(fig. 2)*.

General information is available on symptoms, damage, distribution, and control of dwarf mistletoe in mature red fir (Scharpf 1964). Also some aspects of the biology and pathology of red fir dwarf mistletoe have been investigated (Scharpf and Parmeter 1967). But information about infection and buildup of dwarf mistletoe in young stands and understory trees has not been available.

The Host

In general, natural red fir stands have certain silvical characteristics (Hallin 1957) that are favorable for spread and buildup of dwarf mistletoes. These characteristics may, in part, explain the abundance and severity of dwarf mistletoe in red fir in California:

- Within its normal range red fir grows as pure stands, or, if in mixed stands, often is the predominant species. Therefore, nonsusceptible trees do not limit the spread and buildup of the parasite.
- Red fir forms fairly dense stands, thereby allowing the parasite to spread easily from one crown to another.
- Red fir is intermediate in tolerance and will survive under partially shaded conditions. Understory trees surrounded by infected overstory are readily exposed to infection by dwarf mistletoe.
- Red fir understory trees grow slowly in height until they reach 12 to 15 feet tall; therefore, trees may become badly infected by dwarf mistletoe before they can reach a stage of optimum growth.

The most common method of harvesting red fir has been to clearcut fairly large blocks. But if no residual advance growth is present, the blocks may not be able to regenerate naturally. Whether the use of this cutting technique in large areas is esthetically disirable has—along with the problem of regeneration—led to studies of other systems of managing red fir. Research underway at the Pacific Southwest Forest and Range Station has suggested that other methods of harvesting firs, such as clearcutting in strips, or using seed tree and shelterwood methods, may improve natural regeneration and be more esthetically desirable.

Methods

To study red fir stands infected by dwarf mistletoe, I set up plots on four National Forests: the Stanislaus and Eldorado National Forests in the central Sierra Nevada, Plumas National Forest in the northern Sierra Nevada, and Lassen National Forest in the southern Cascades. These forests had infected stands that are representative of others in the State. Square 1/10-acre plots were established in pure red fir stands *(table 1)*. Information on density of stocking was obtained from a 1/100-acre subplot taken from the center of each of the 38 plots.

Three criteria were used to select the plots:

1. Heavily infected overstory had to be present on the plot. Dwarf mistletoe throughout the crown, broomed branches, and bole swellings on overstory trees were considered indicative of heavy infection.
2. Adequate understory trees up to 12 feet tall had to be present to obtain the desired number of sample trees in each height class.
3. Because the distance of spread of dwarf mistletoe from infected overstory to understory trees is limited, all understory trees on the plots had to be within 100 feet of at least one heavily infected overstory tree.

Trees to be sampled on each plot were randomly selected. For each tree desired, two coordinates were drawn from a table of random numbers and the points defined by these numbers located on a map of the plot. The 20 points were then located on the ground. The tree in the desired height class nearest a point was chosen as a sample tree. Five trees were chosen in each of the four height classes (0–3 ft., 4–6 ft., 7–9 ft., 10–12 ft.). Thus, with only a few exceptions, 20 trees from each plot were obtained.

The following data were collected in the field for each sample tree: tree height, number of infections per infected tree, and type of infection (bole or branch). Tree age was determined in the laboratory by counting the number of annual rings in a cross-sectional disc cut from the bole of the tree at ground level.

Results

The percentage of trees infected and number of infections per infected tree were directly related to tree height *(figs. 3, 4)*. Only 7 percent of the understory trees in the 0- to 3-foot height class were infected. On infected trees, a mean of only slightly more than one infection per tree (1.4) was found. Percentage of trees infected increased markedly above the 0- to 3-foot height class, and number of

Table 1.--*Plots set up to study dwarf mistletoe infection, by National Forest*

National Forest	Elevation	Location	Plots	Trees	Average understory trees/acre
	Feet		*number*		
Stanislaus	7,000	Near Pinecrest 30 mi. E. of Sonora	10	196	1,950
Eldorado	7,000	Near Lower Bear Reservoir	8	156	1,300
Plumas	5,700	5 miles west of Bucks Lake on Oroville-Quincy Road	10	195	3,470
Lassen	6,000	Swain Mountain Exp. Forest	10	193	2,570

infections per tree also increased significantly on trees above the 4- to 6-foot class. For the tallest trees examined (10- to 12-foot class), nearly 4 of 5 were infected, with a mean of about 11 infections per tree.

Age of understory trees appeared to have little effect on percentage of trees infected *(fig. 5)*. Only in one age class (0-20 years) were significantly fewer trees infected than in the other classes. As tree-age classes increased from 21 to 100 years, the increase in percentage infection was only about 20 percent. Too few trees more than 100 years were sampled to obtain any statistically significant results for this age class.

Trees in the 0- to 20-year age class had the fewest number of infections per infected tree *(fig. 6)*. Number of infections per infected tree appeared to increase somewhat for trees up to 60 years old, but afterwards dropped off slightly and then remained constant. Again, I did not obtain enough data on trees more than 100 years old to draw any significant conclusions about this age class.

Bole infections constitute the most serious type of infection on firs, even though only 6 percent of all infections recorded were bole infections. Bole infections deform small trees, cause pronounced swellings on larger trees, and eventually provide an opening for decay fungi, which makes boles par-

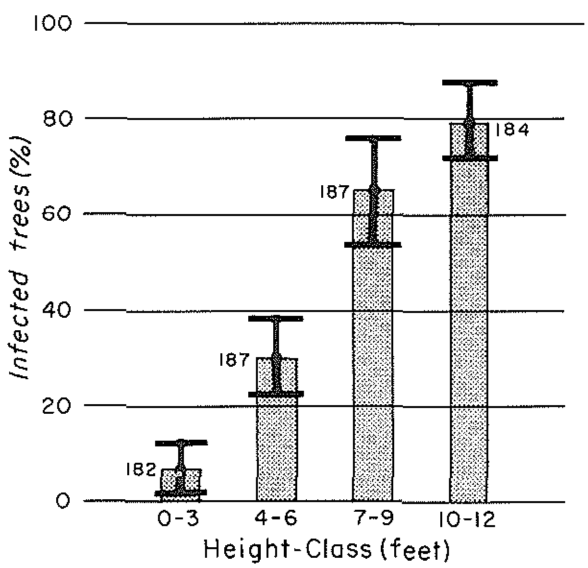


Figure 3.—*Percentage of red fir infected in each height-class, with 95 percent confidence intervals. The confidence intervals were interpolated from a table of intervals for estimates of the binomial parameter by Hald (1952).*

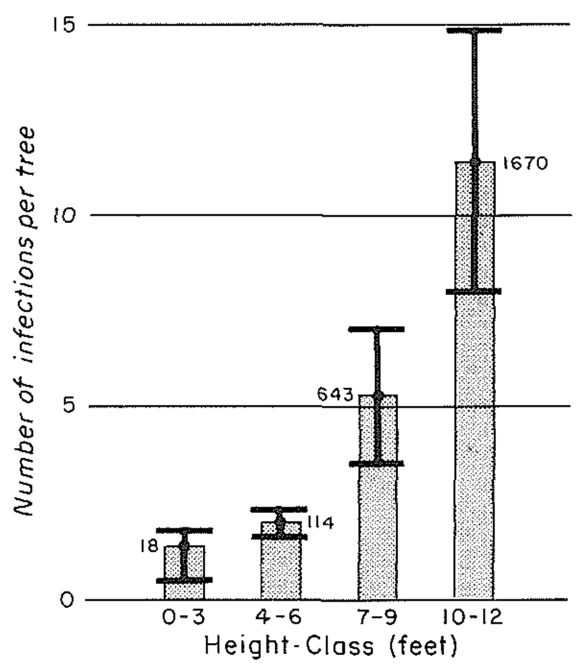


Figure 4.—*Number of infections per infected tree in each height-class, with 95 percent confidence intervals.*

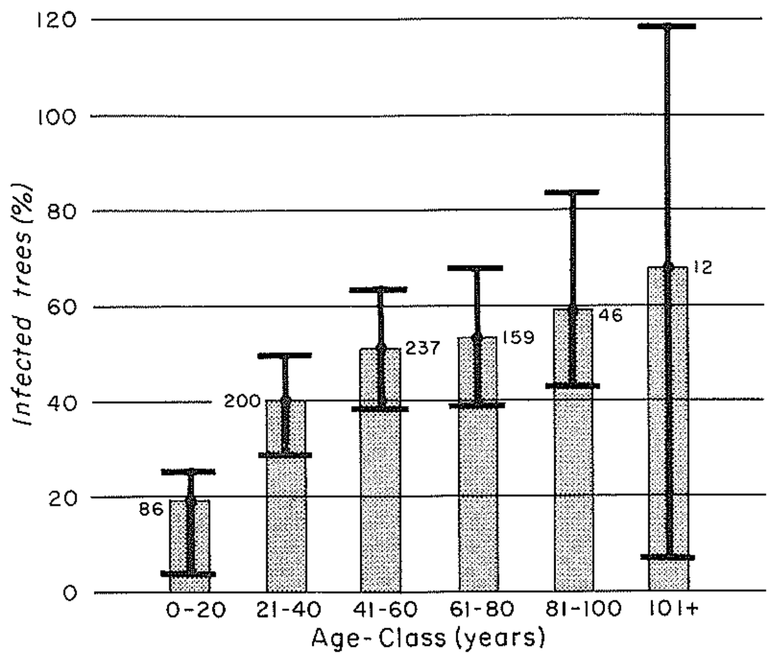


Figure 5.—*Percentage of firs infected in each age-class, with 95 percent confidence intervals.*

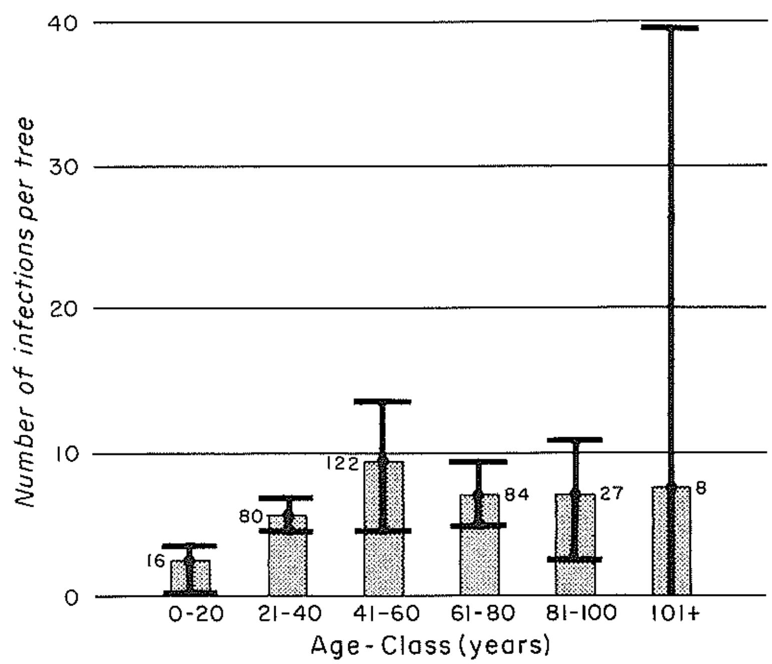


Figure 6.—*Number of infections per infected tree in each age-class, with 95 percent confidence intervals.*

ticularly susceptible to wind breakage. Considerable loss in timber volume and quality results from bole infections.

Incidence of bole infections was directly related to tree height *(fig. 7)*. Only 1 percent of all trees in the 0- to 3-foot height class had bole infections. Only 5 percent of the 4- to 6-foot trees were infected. And in the 6 feet and taller class, the percentage of trees with bole infections appeared to increase markedly.

Except in the youngest age-class, incidence of bole infection appeared to have little relation to age of tree *(fig. 8)*. Trees up to 20 years old were relatively free of bole infections. In all other age classes, the proportion of trees with bole infections remained nearly constant.

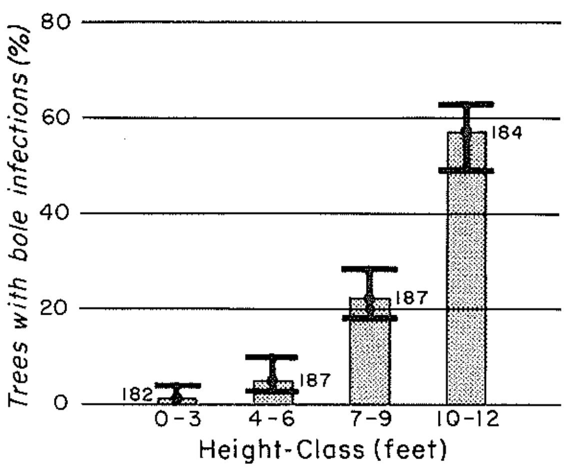


Figure 7.—*Percentage of all trees, by height-class, with one or more bole infections, with 95 percent confidence intervals.*

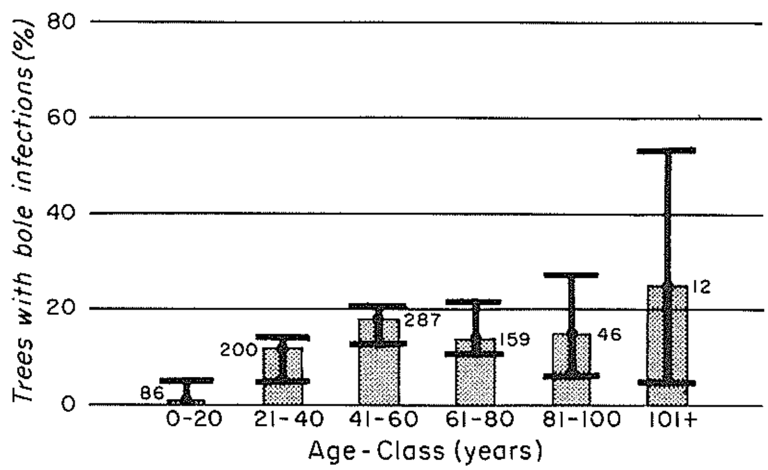


Figure 8.—*Percentage of all trees, by age-class, with one or more bole infections, with 95 percent confidence intervals.*

Discussion

Results of this study agree with those of other investigators (Childs 1963; Hawksworth 1958; Scharpf 1968; and Wicker and Shaw 1967). Infection of understory trees by dwarf mistletoe was directly related either to target area or to tree height. Consequently, the dominant understory trees in a stand were the most severely attacked. Childs (1963) and Wicker and Shaw (1967) considered tree age, or length of time that understory trees are exposed to infection, to be a factor that influenced the infection of conifers. In red fir, I found this factor applicable in only youngest age classes. In trees 20 years or older, age appeared to have only slight influence on percentage of firs infected. And on infected trees older than 40 years, there appeared to be no marked difference in mean number of infections per tree.

Once understory trees become infected, intensification usually takes place from newly established, seed-producing female plants. Probably the greater number of infections on the taller trees can be explained in part by the intensification of the parasite from within the tree crown *(fig. 4)*. But, why the number of infections did not increase strikingly as tree age increased is not fully understood *(fig. 6)*. Perhaps tree vigor—as expressed by height growth rather than tree age—is an important factor in the development of robust female plants and in subsequent intensification by the parasite.

Scharpf and Parmeter (1967) found that the incubation period before infections on red fir become established and are readily visible may be as long as 5 years. Thus, some seemingly uninfected trees may have latent infection. But because tree age appears to have limited influence on infection and because small firs grow only slightly in height in 5 years, the proportion of small trees appearing uninfected but bearing latent infections probably is quite low.

The relationship between tree height and tree age and bole infections was about the same as that to branch infections. This finding was expected because field observations showed that bole infections arise mainly from growth of branch infections into the bole. Only occasionally are they the result of direct infections of the bole. Thus, the more infections that occur on a tree, the more likely the tree will eventually become infected in the bole. Because trees with bole infections usually die, become suppressed, or are of inferior timber quality, forest managers should try to hold dwarf mistletoe to a low level in a stand to avoid bole infection.

The infection that was studied in understory trees occurred in the presence of heavy overstory infection. Under less severe overstory infection or in mixed stands where some screening from dwarf mistletoe occurs, somewhat lower rates of infection of understory stands probably can be expected.

Suggestions for Control

Forest managers are concerned primarily with minimizing the damage from dwarf mistletoe in the residual stand after logging or with preventing the parasite from developing in noninfected stands. From results in this study, I can suggest several approaches to silvicultural control that should help reduce spread of and damage from these parasites in either the residual or in newly established stands.

These approaches to control are based on the knowledge that tree height is related to infection of understory red fir by dwarf mistletoe.

• In infected, pure red fir stands with little understory:

1. Clearcut narrow strips or small blocks of old-growth. Plant the cut areas or allow them to regenerate naturally. Once the new stand is well established and certainly before the trees reach 3 feet in height, return and harvest adjacent infected stands to prevent infection of trees at the margins of the regenerated areas.

2. Harvest infected old-growth stands by selection or seed-tree methods of logging to provide for natural regeneration.

Use as many noninfected trees as necessary or possible as a seed source. If infected seed trees are used and after the area has regenerated naturally but before the understory trees are 3 feet tall, harvest or fell the infected seed trees to prevent further infection of the new stand.

• In infected, pure red fir stands with considerable understory:

Clearcut stands with little regard for saving trees more than 3 feet tall. Sapling and pole-size trees should be "walked down" with heavy equipment or removed in some other manner during or after logging to eliminate the badly infected component of the understory. Avoid leaving any infected overstory unless it is needed for regenerating understocked areas. Immediately after adequate regeneration, remove the infected overstory to prevent further spread of the parasite in the advance growth left after logging.

• In mixed stands where infected red fir is the predominant species:

Harvest the merchantable red fir, leaving the noninfected overstory species as a seed source for regeneration if adequate understory will not be present after logging. Do not attempt to save saplings and poles of the infected species but do, if possible, avoid destroying any of the nonsusceptible understory trees. If infected overstory trees are left as a seed source they should be retained only until the regeneration is well established. If, however, the area becomes regenerated by a species other than red fir, the infected fir overstory can be left in place without fear of infection of the new seedlings.

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