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Spread of Dwarfmistletoe into Jeffrey Pine Plantation . . .

trees infected after 22 years

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ABSTRACT: A study at the Institute of Forest Genetics, Placerville, Calif., showed that dwarfmistletoe could spread from infected overstory ponderosa pine into planted Jeffrey pine--a maximum distance of about 145 feet. About one-third of the trees within this distance were infected after 22 years. The level of infection in the trees remained low, however, and the parasite had intensified only slightly. Dwarfmistletoe did not appear to have affected height growth. Differences in degree of infection were noticed among blocks of trees from different altitudinal zones.

RETRIEVAL TERMS: *Arceuthobium campylopodum;* build-up(infection); disease control; dwarfmistletoe; *Pinus jeffreyi; Pinus ponderosa;* plantations; spread(infection).

Dwarfmistletoe (*Arceuthobium campylopodum* Engelm. f. *campylopodum* [Engelm.] Gill) is a serious parasite of both Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.) and ponderosa pine (*P. ponderosa* Laws.) in California. It can usually be controlled by clearcutting mature infected stands. But often natural or planted reproduction at the margins of clearcut areas becomes infected by the parasite in the adjacent uncut infected stands. If the forest manager knew the distance of spread of dwarfmistletoe and how much infection was likely to occur, he could take the necessary control measures.

In 1961, we made a study of dwarfmistletoe spread and buildup in a plantation of ponderosa pine and Jeffrey established in 1940 at the Institute of Forest Genetics, Placerville, Calif. Aims of the study were to determine the maximum distance of spread of the parasite from infected overstory into the plantation, amount of infection and its distribution within the plantation, and relationship between height growth of trees and degree of dwarfmistletoe attack.

We found that dwarfmistletoe could spread more than 100 feet from infected overstory into plantation trees, where about a third of the trees became infected. Level of infection was generally low. Groups of trees from different altitudinal zones in the Sierra Nevada showed varying degrees of infection.

Study Area and Methods

The U.S. Forest Service's Institute of Forest Genetics is located about 4 miles east of Placerville, California, and at an elevation of about 2,700 feet. The plantation of ponderosa pine and Jeffrey pine studied there was established by using 2-0 stock. Seed for the stock was from several parent trees from various elevations in the central Sierra Nevada. Seedlings from a given altitudinal zone were planted in blocks (Mirov et al. 1952). Each block contained 16 trees spaced 8 feet apart and the blocks were separated from one another by a 16-foot zone (fig.1). Blocks in rows 1 and 2 were planted to Jeffrey pine. A border of Jeffrey pines 8 feet apart and 16 feet from the blocks was planted around the southern and eastern portion of the plantation. These border trees were not recorded by altitudinal zone.

Since 1940 the plantation has become infected by dwarfmistletoe originating from heavily infected overstory ponderosa pine near its southeast border (figs. 1,2).

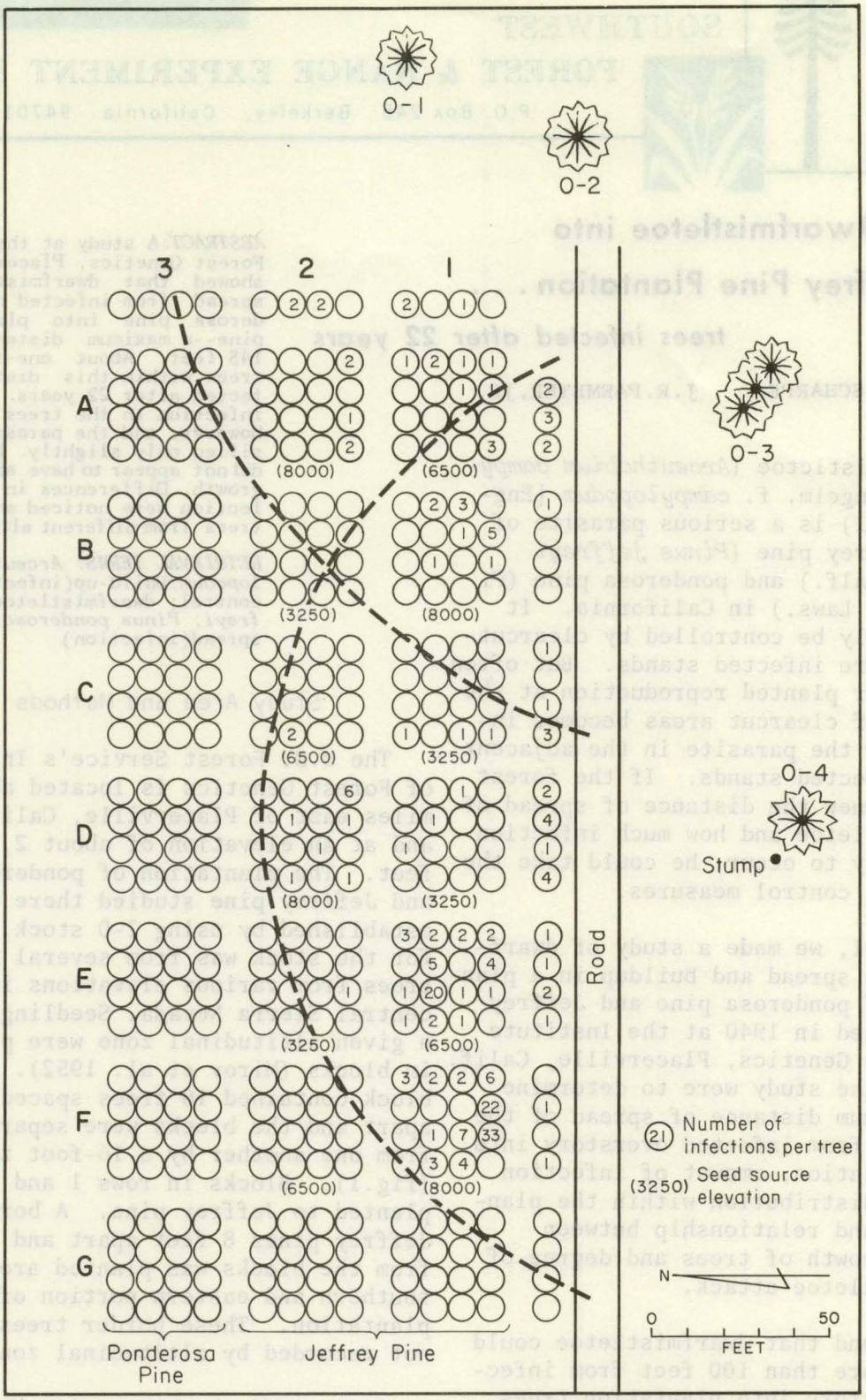

Figure 1.--*Southeast portion of plantation infected by dwarfmistletoe. Dash lines indicate direction and maximum estimated distance of spread from overstory trees.*

Slope of the area is about 26 percent from north to south in the direction of the infected overstory, but it is nearly level east to west. Tree growth has been fair and mortality low. Measurements of height growth have been made by Institute personnel at 3, 5, 7, 8, 12, 20, and 25 years after germination. In 1951 all plantation trees were pruned to a height of 8 feet. Some dwarfmistletoe-infected branches were removed at the time of pruning. At the time of the study in 1961 the trees averaged about 25 to 30 feet tall.

Observations of infection in the plantation were made from the ground with the unaided eye. Binoculars were used to examine adjacent overstory trees. The height of infection in the overstory trees was determined with an Abney level. Age was determined from increment borings made at ground level. The distance and direction of overstory trees from the plantation were also determined. The number of infections on each plantation tree was recorded.

Height growth of plantation trees in relation to degree of infection was examined in detail for blocks 1E and 1F (fig. 1).

Results

Infection was heavy in all overstory trees as evidenced by numerous branch infections and the presence of old, well-developed brooms (fig. 2). Information on overstory trees and infection is as follows:

Overstory	Age	Distance from edge of plantation	Maximum height	
			Tree	Infection
		(feet)		
0-1	88	69	87	72
0-2	82	46	88	51
0-3[1/]	90	58	113	72
0-4[2/]	89	74	94	62

[1] Three trees.

[2] Stump in fig. 1 is from an insect-killed pine removed early in the life of the plantation.

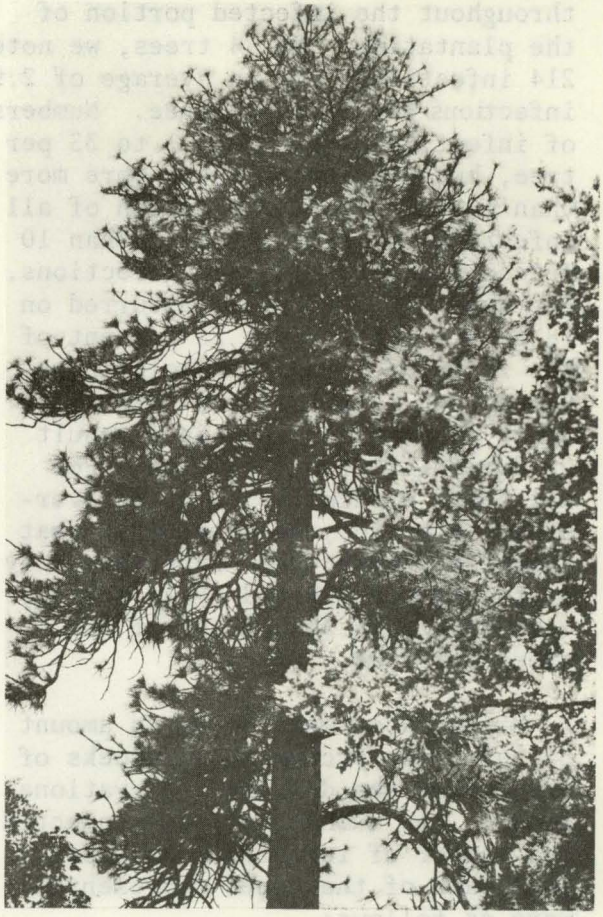

Figure 2.--*Heavy infection of dwarfmistletoe in overstory ponderosa pine. (Tree 0-4 in fig. 1.)*

Plantation trees infected with dwarfmistletoe were found only in the rows of blocks 1 and 2 along the southern part of the plantation and only in the border rows at the southeast corner, near the infected overstory (fig. 1). Infection occurred only in the blocks of Jeffrey pine. The primary direction and maximum estimated distance of spread of the parasite from overstory trees were as follows:

Overstory	Spread	
	Direction	Distance
		(feet)
0-1	W	143
0-2	W,NW	125
0-3	N,NW	133
0-4	N,NW	145

In general, infection was light throughout the infected portion of the plantation. On 74 trees, we noted 214 infections, for an average of 2.9 infections per infected tree. Numbers of infection ranged from 1 to 33 per tree, but only three trees bore more than 10 infections. Nineteen of all infections or slightly less than 10 percent occurred as bole infections. But these 19 infections occurred on 18 trees. Thus about 25 percent of the infected trees bore bole infections. No mortality was noticed among plantation trees as a result of dwarfmistletoe infection. For all trees within the range of overstory infection, we determined that about 36 percent were infected. Only in two blocks (1E and 1F in fig. 1) were more than 50 percent of the trees infected.

Differences were noted in amount of infection occurring in blocks of trees from the different elevational zones. The number of trees infected and number of infections on trees from each of the zones represented were as follows:

Eleva. zone (ft.)	Trees infected	Infections	Av. infections/tree
	(number)		
3,250	7	7	1.0
6,500	21	57	2.7
8,000	25	112	4.5

Noticeably fewer trees were infected and fewer infections occurred per infected tree in blocks from the 3,250-foot elevational zone.

Reduction of height growth as a result of dwarfmistletoe infection was not detected. Trees growing most rapidly in height were those that bore the greatest number of infections (fig. 3). Uninfected trees showed the slowest rate of growth.

Discussion and Conclusions

Results of this study suggest that distance of spread of *A. campylopodum* from overstory to understory trees is considerably greater than that reported for *A. vaginatum* (Willd.) Presl f. *cryptopodum* (Engelm.) Gill in the Southwest.

Gill and Hawksworth (1954) found for *A. vaginatum* on ponderosa pine that nearly all infected reproduction was within 60 feet of the infected overstory trees. On another area mean spread from overstory to dense understory was 51 feet and to open grown understory 59 feet (Hawksworth and Gill 1960). Hawksworth (1961) found that the maximum distance of spread was 86 feet in one 10-year-old stand, but the maximum distance for several areas averaged 42 feet.

Distance of spread of dwarfmistletoe in California more closely approximated that found by Roth (1953) in Oregon. He found that maximum spread from overstory ponderosa pines, averaging 120 feet tall, to understory was 130 feet in the direction of the prevailing winds. Beyond 33 feet, however, infection was moderate to light. Wind probably was an important factor in long distance spread to plantation trees from adjacent infected overstory.

Buildup of dwarfmistletoe has received some attention. Wagener (1965) suggested that in young stands of pine in California, buildup of low levels of *A. campylopodum* will be slow in the absence of overstory infection. Pruning of the plantation at the Institute in 1951 may have been partially responsible for the lack of buildup of the parasite. Had the trees not been pruned, possibly much more spread and intensification of the parasite would have taken place in the succeeding 10 years.

The higher proportion of trees infected and the greater number of infections on trees from the higher elevational zones could not be explained on the basis that these blocks of trees were closer to the overstory source of infection (fig.1).

Similarly, differences in amount of infection on trees from the various elevational zones could not be attributed to pronounced differences in growth rate of trees in the blocks (Callaham and Metcalf 1959; Callaham and Liddicoet 1961). Hawksworth (1961), Roth (1953), and Wagener (1965) have pointed out that individual trees in heavily infected stands occasionally show resistance to dwarfmistletoe. It is not unlikely therefore, that populations of trees from different altitudinal zones may display different degrees of resistance to infection by dwarfmistletoe.

The greater height growth of infected trees should not be interpreted as a stimulation of growth resulting from infection. Rather, taller trees and trees with dense crowns present a greater target area and are more likely to become infected than the smaller somewhat suppressed trees (Childs and Wilcox 1966). Until the natural variation in growth of Jeffrey pines is studied in more detail, an accurate estimate of the impact of dwarfmistletoe on young-tree growth would--at best--be risky.

Some general conclusions are, nevertheless, possible:

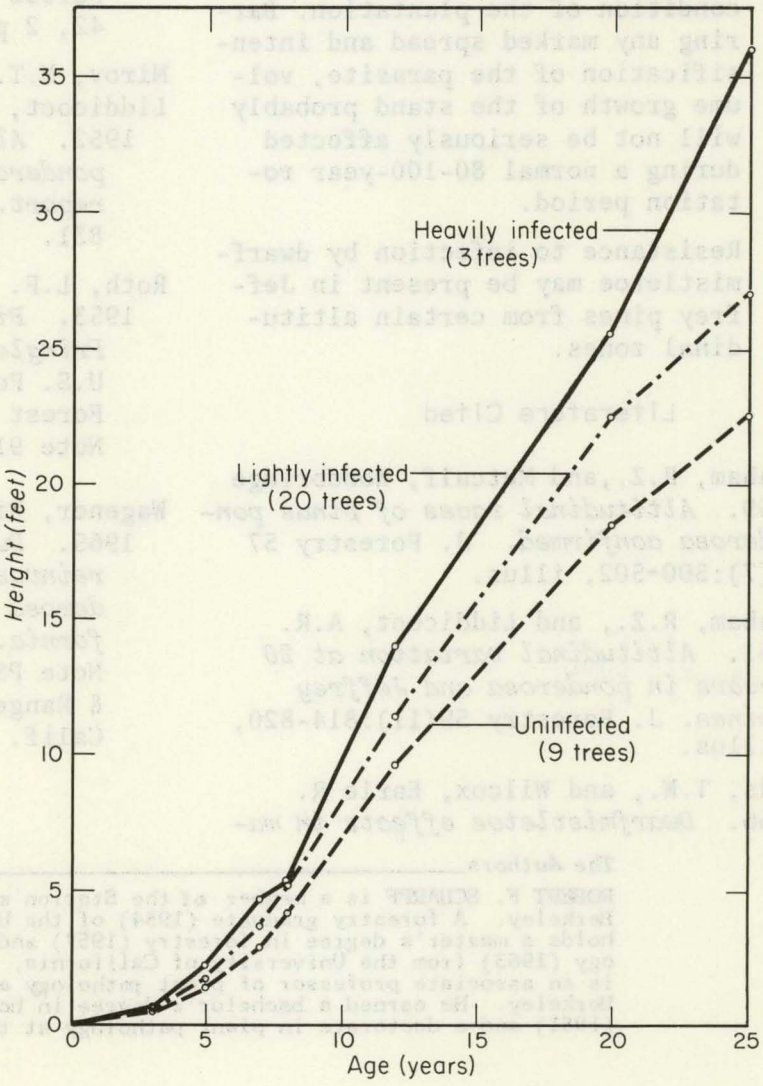

Figure 3.--*Mean height growth of dwarfmistletoe-infected and noninfected Jeffrey pines (Blocks 1E and 1F in fig. 1).*

- *A. campylopodum* was able to spread effectively to understory trees for a distance equal to about twice the height of the infection in the overstory.
- Within these distances, a fairly high proportion of understory trees became infected. During the first 22 years of tree growth, however, the parasite showed only limited buildup. And, provided the infected overstory is removed, future spread and buildup of the parasite should be slow.
- Adverse effects on height growth by dwarfmistletoe was not detected under the particular growing condition of the plantation. Barring any marked spread and intensification of the parasite, volume growth of the stand probably will not be seriously affected during a normal 80-100-year rotation period.
- Resistance to infection by dwarfmistletoe may be present in Jeffrey pines from certain altitudinal zones.

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