EFFECTS OF MISTLETOE AND OTHER DEFECTS ON LUMBER QUALITY IN WHITE FIR[1]

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ABSTRACT

The presence or absence of defects, including dwarf and true mistletoes, was determined for logs from twenty white fir trees. Grade and volume were determined for all boards sawed from these logs. Differences between defect categories and logs without defect, with regard to degrade and overrun, were not statistically significant. With the exception of shop grades derived from logs containing dwarf mistletoe, differences between logs without defect and those with defect were not statistically significant after the effect of diameter was accounted for; even in this single exception, the volume derived from dwarf mistletoe logs was greater than that derived from no-defect logs. This suggests that the presence in logs of dwarf mistletoe, true mistletoe, and the other defects considered in this study either does not adversely affect lumber grade or that present quality control procedures are ineffective in detecting the changes. The latter possibility appears most likely.

Additional keywords: *Abies concolor*, lumber grade recovery, overrun.

INTRODUCTION

Mistletoes, primarily dwarf mistletoes, have long been recognized as serious threats to the production of coniferous timber (Hawksworth and Wiens 1972). Often the result of mistletoe infection is a lasting deformation of the tree rather than outright killing. As a consequence it is necessary to utilize wood that has been affected by the mistletoe infection.

The morphological changes in wood tissue associated with dwarf mistletoe attack have been studied previously. For example, reports indicate in mistletoe-infected tissue increased size and number of rays (Dufrénoy 1936; Srivastava and Esau 1961); abnormal tracheid development (Dufrénoy 1936), including decrease in length (Smythe 1967; Srivastava and Esau 1961); increased numbers of resin canals (Srivastava and Esau 1961); and an increased microfibril angle in tracheid secondary walls with a concomitant increase in longitudinal shrinkage (Piirto 1971).

Some observations of gross properties associated with dwarf mistletoe, which would be expected to affect wood product quality, have been made, including increased quantity of pitch or other alcohol-benzene-extractable substances (Hawksworth 1961; Korstian and Long 1922; Piirto 1971), deviated or curly grain and an increase in the number and size of knots (Boyce 1961; Korstian and Long 1922), and brashness (Hawksworth 1961). The specific gravity of tissue associated with dwarf mistletoe infection generally appears

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to be higher than that of normal wood (Hawksworth 1961; Piirto 1971; Smythe 1967; Wellwood 1956), but lower specific gravity in severe infections, probably due to the action of introduced decay fungi, has been reported (Wellwood 1956).

Although many of the foregoing observations suggest that dwarf mistletoe-infected wood would be weaker, only recently have strength tests been performed on such tissue. Piirto (1971) found that the moduli of elasticity and rupture and work to the proportional limit all were lower in mistletoe-infected wood than in noninfected wood. Furthermore, Piirto reported that even noninfected wood from infected trees had altered properties in relation to wood from trees that had no dwarf mistletoe infections.

These data all suggest that wood from mistletoe-infected trees might be of inferior quality and might be expected to develop defects during processing. However, to our knowledge no studies of the relationship between mistletoe infection and wood quality and yield have previously been performed. In conjunction with a larger study (Pong 1971; Wilcox and Pong 1971) on wood properties and lumber quality in white fir (*Abies concolor* Gord. and Glend. (Lindl.)), it was possible to correlate lumber quality with the occurrence of dwarf mistletoe (*Arceuthobium abietinum* f. sp. *concoloris* Hawksworth and Wiens), true mistletoe (*Phoradendron bolleanum* subsp. *pauciflorum* (Torr.) Wiens), frost cracks, cankers (other than those obviously caused by mistletoe), and "bleeding" of liquid from branch stubs, frost cracks, and other wounds. This paper reports the results of that portion of the study dealing with the effects of those defects upon yield, grade, and degrade in the boards sawed from defective logs.

MATERIALS AND METHODS

Twenty white fir trees from El Dorado County, California, representative of the range of diameters and heights of trees commonly logged in that area, were selected for the study. The trees were from a relatively young stand and good site as indicated by the following data: they varied in age from 79 to 176 years, with a mean of 131; in height from 88 to 182 feet, with a mean of 131; and in DBH from 17.2 to 46.9 inches, with a mean of 30.7.

The location of all defects was carefully diagrammed by methods previously described (Jackson et al. 1963; Pong and Jackson 1971) both in the standing trees and bucked logs. In addition, the trees after felling and the logs before sawing were inspected carefully for evidence of infection by dwarf or true mistletoe. The location on the log and the extent of swelling or other defects associated with infection were noted. Logs were graded into three mistletoe intensity classes (light, moderate, and heavy) according to the number, length, degree of swelling, and state of deterioration of infections. Eight of the logs with dwarf mistletoe and six of the logs with true mistletoe had, in addition, defects that would have caused them to be placed in the "other defects" category; however, they were considered solely as members of the appropriate mistletoe category on the assumption that this was potentially the most serious defect. The term "no detectable defect" was applied to those logs that lacked external indicators of defect. Some such logs may, in fact, have contained defects that were not externally detectable, but from a log grading standpoint they were considered nondefective.

The identity of each board, with respect to the tree and log from which it was produced, was maintained throughout all stages of processing. A photographic record (Pong et al. 1970) of each board was used to determine the grades and volumes of lumber from each log in the rough-green, rough-dry, and surfaced-dry conditions. The data were analyzed by analysis of variance and covariance using the program NYBMUL (Finn 1968; Anon. 1969) and the University of California, Berkeley, CDC 6400 computer. Dunn's multiple comparison procedure (Kirk 1968) was used to determine which simple pairwise

TABLE 1. *Effect of defect on degrade*

Type of Defect	Number of logs in sample	Mean degrade[a] %	Mean for defect class %
No detectable defect	56	43.7	43.7
Dwarf mistletoe			
Light	6	41.0	
Moderate	4	59.3	46.3
Heavy	2	35.9	
True mistletoe			
Light	16	42.4	
Moderate	8	56.2	47.8
Heavy	2	57.1	
Other defects	18	40.5	40.5

[a]Percentage of rough-green lumber volume (bd ft) placed in a lower grade when in the surfaced-dry condition.

comparisons between levels of a variable contributed to a significant F statistic; the proportion of the total variation accounted for by each variable ($\hat{\omega}^2$) also was computed (Kirk 1968, p. 134).

RESULTS AND DISCUSSION

A summary of the effect of defect upon degrade (boards placed in a certain grade when rough green and then reassigned a lower grade after drying and surfacing) is shown in Tables 1 and 2. Although there was a tendency for greater degrade to occur in lumber from logs containing dwarf and true mistletoe than from logs without defects (Table 1), differences in degrade between the four defect groups were not statistically significant (Table 2). Separate analyses of variance revealed that differences in the amount of degrade at intermediate stages of processing (rough-green to rough-dry, rough-dry to surface-dry) also were not significant.

TABLE 2. *Analysis of variance for data represented in Table 1*[a]

Source	SS	df	MS	F
Defect				
Between	628.58	3	209.53	0.61
Within	37,304.39	108	345.41	
Total	37,932.97	111		

[a]Only the four primary classes of defect are included in the analysis ("Mean for defect class" column of Table 1).

TABLE 3. *Grade distribution of surfaced-dry lumber volume in each defect class expressed as per cent of total volume from logs in each defect class*

Grade	Type of Defect			
	No detectable defect	Dwarf mistletoe	True mistletoe	Other defects
Clear	7.2	5.3	0.4	12.8
Shop	9.0	24.2	5.2	23.0
Dimension	82.7	66.8	91.3	60.0
Cull/Dunnage	1.1	3.7	3.2	4.2
Total (%)	100	100	100	100
Total (bd. ft.)	18,203	5,435	8,119	10,384

The distribution of grades resulting from the total volume of logs in each defect category is shown in Table 3. More volume in clear and shop grades came from dwarf mistletoe and other defect logs than from logs without defect, while true mistletoe logs produced less volume in these grades than did logs without defect. Since the three categories of defect may appear in different portions of the tree, the distribution of mean height in the tree and log diameter against defect categories was determined (Table 4). Dwarf mistletoe and other defect logs appeared to come from lower in the tree and to be of larger diameter than logs without defect, while true mistletoe logs tended to come from higher in the tree and have a smaller diameter than logs without defect. Grade

TABLE 4. *Position in the tree and diameter of logs by defect category*

Type of Defect	Log Position[a]	Mean Log Diameter[b]
No detectable defect	3.8	22.3
Dwarf mistletoe	2.7	25.7
True mistletoe	5.5	21.4
Other defects	2.0	30.4

[a]In 16-ft lengths from ground

[b]Inches at large end

TABLE 5. *Mean lumber grade and volume by defect class*

Variable	Type of Defect							
	No detectable defect		Dwarf mistletoe		True mistletoe		Other defects	
	$\bar{x}$	$\bar{x}_{adj}$	$\bar{x}$	$\bar{x}_{adj}$	$\bar{x}$	$\bar{x}_{adj}$	$\bar{x}$	$\bar{x}_{adj}$
Mean per cent of surfaced-dry volume per log in each grade (volume in each grade as per cent of total volume for that log)								
Clears	3.5	5.0	3.1	2.7	0.2	2.2	9.7	6.5
Shop	4.6	7.2	15.4	14.7	2.4	6.1	17.6	12.0
Dimension	91.1	86.6	76.9	78.1	96.1	90.0	69.8	79.2
Cull/Dunnage	0.8	1.2	4.6	4.5	1.3	1.8	2.9	2.2
Mean surfaced-dry lumber volume per log (bd ft)	325	403	453	432	312	418	577	415
Mean green lumber volume per log (bd ft)	330	410	468	447	319	428	594	426
Mean net log scale per log (bd ft)	268	337	388	370	232	325	486	342
Mean overrun (per cent)	32	28	24	25	40	35	25	32
Number of logs studied	56		12		26		18	

and volume both are affected by log diameter; furthermore, analysis of variance showed that diameter accounted for more of the total variation in grade and volume than did defect. Therefore, analysis of covariance was performed for defect with log diameter as covariate. Both the observed and adjusted means for grade and volume measurements on logs in each defect category are shown in Table 5 and results of the analysis of covariance appear in Table 6.

These data indicate that differences between defect classes for all dependent variables, except for the volume in shop and dimension grades, were not statistically significant when the effect of diameter was removed. With regard to volume in shop and dimension grades, Dunn's procedure applied to the adjusted means indicated that the significant pairwise comparisons were: no defect vs. dwarf mistletoe and true mistletoe vs. dwarf mistletoe for shop; true mistletoe vs. dwarf mistletoe and true mistletoe vs. other defects for dimension. It can be seen from Table 5 that, even for the one comparison with logs without defect that is significant (shop: no defect vs. dwarf mistletoe), the difference lies in a direction just the opposite of that which would be expected under the assumption that such defect has a deleterious effect upon lumber quality. For dwarf mistletoe in particular, this suggests either that the mistletoe does not induce changes in wood that adversely affect the quality of the product or that current procedures of quality control are ineffective in detecting the changes. In light of the changes in anatomical and mechanical properties reported in the literature as being caused by dwarf mistletoe infection, the latter possibility appears most likely.

Although the study involved the collection of detailed data on more than 2,000 boards at three stages of processing, the sample does represent only 20 trees and as few as 12 logs in a single defect category. The sample size should be considered in interpreting the data; however, it is questionable whether the recommendation of a large sample in future work of this type is a reasonable suggestion in light of the amount of work involved. These

TABLE 6. *Analysis of covariance for defect, with log diameter as covariate*

Variable	Source	SS	df	MS	F[a]	$\hat{\omega}^2$
Clears	Between	250.07	3	83.36	1.82	
	Within	4,895.80	107	45.76		
	Total	5,145.87	110			
Shop	Between	840.62	3	280.21	4.81**	0.093
	Within	6,228.76	107	58.21		
	Total	7,069.38	110			
Dimension	Between	1,728.48	3	576.16	5.08**	0.099
	Within	12,140.65	107	113.46		
	Total	13,869.12	110			
Cull/Dunnage	Between	108.71	3	36.24	1.96	
	Within	1,980.84	107	18.51		
	Total	2,089.55	110			
Surfaced-dry volume	Between	10,490.94	3	3,496.98	0.44	
	Within	844,071.28	107	7,888.52		
	Total	854,562.21	110			
Green volume	Between	16,014.22	3	5,338.07	0.61	
	Within	929,947.52	107	8,691.10		
	Total	945,961.74	110			
Net log scale	Between	15,927.64	3	5,309.21	0.78	
	Within	726,173.84	107	6,786.67		
	Total	742,101.48	110			
Overrun	Between	1,215.57	3	405.19	0.73	
	Within	59,521.20	107	556.27		
	Total	60,736.77	110			

[a] **$p < .01$

results do show the need for adequate statistical control of such data and the need for applying the techniques used here to determine the significance and impact of various disease conditions on lumber quality. They also suggest that we should perhaps reevaluate the methodology employed in quality control for those products where serviceability and reliability are important use criteria.

CONCLUSIONS

At first glance, the mean values representing the data of this study suggest several conclusions concerning the effect of mistletoe and other defects on lumber yield and quality. Most of the observed differences, however, proved not to be statistically significant. Lumber from logs containing dwarf and true mistletoe appeared to suffer greater processing degrade than that from logs without defect, but the differences were not statistically significant. Logs containing true mistletoe produced a smaller proportion of boards in clear and shop grades than logs without defect; these differences too were not significant when the effect of diameter was accounted for. Logs containing dwarf mistletoe or other defects (frost cracks, other cankers, and "bleeding") tended to produce a greater proportion of high grade boards than logs without defect; these differences were significant only for shop grades after the effect of diameter was accounted for. Overrun appeared higher in logs with true mistletoe and lower in those with dwarf mistletoe than in logs without defect, but these differences also were not significant when the effect of diameter was removed. Although slightly more wood was lost in processing dwarf mistletoe and other defect logs than was true for logs in the other two categories, these differences as well appeared to be due more to phenomena associated with log diameter than with defect. These data suggest, therefore, that the presence in logs of dwarf mistletoe, true mistletoe, and the other defects considered as a group in this study either does not adversely affect lumber quality, or that present quality control procedures are ineffective in detecting the changes. The latter is more likely to be true.

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