THE EFFECT OF AMBROSIA BEETLE DAMAGE UPON LUMBER VALUE

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A GREAT deal of fundamental work has been carried out on the life history and habits of the various species of Ambrosia beetles found in British Columbia but no estimate of the loss in lumber value caused by the damage they do has been made.

It is known, however, that the infestation of logs by Ambrosia beetles has caused serious losses in the lumber industry by degrade of lumber, by exclusion of infested lumber from certain markets, by higher cull factors in scaling, and by lower yields of lumber owing to heavy slabbing in the sawmill.

This problem has existed for many years but has been accepted as merely another hazard the lumber industry must face. Within the last year the rising cost of production caused a renewed interest in the problem and as a result, this study was undertaken on a co-operative basis by the Dominion Forest Insect Laboratory, Department of Agriculture, Victoria, the Vancouver Laboratory of the Forest Products Laboratories of Canada, and a co-operating sawmill. This report deals with the loss in grade and value of lumber from logs which had suffered a comparatively mild attack by Ambrosia beetles.

History of Logs

Logs covered by the study came from an even-aged stand of Douglas fi and western hemlock, approximately 270 years old, cut near Port Renfrew, B. C. Some were cut in July, 1948, cold-decked in October, and taken out of the woods in June, 1949. The others were cut in October, 1948, and taken out in June, 1949. All were rafted together and delivered in Victoria, B. C., where they were cut in the sawmill of the co-operating firm during July, 1949.

The logs showed a mild to light attack by Ambrosia beetle **Trypodendron cavifrons**, with only a few additional holes made by **Gnathotrichus sulcatus**. **Trypodendron** attacks all commercial conifers in British Columbia, the active period being from early April to mid July. The attacks are usually very concentrated and it is not uncommon to find intensities of 100 to 200 holes per square foot of surface area.

The tunnels are completely excavated in about three weeks, after which no further damage is done. The galleries usually are branched in the form of an inverted "Y" and occasionally there are three branches. The branches cross the annual rings obliquely but the whole system of galleries from any one entrance hole remains in a single plane at right angles to the vertical axis of the tree. In western hemlock and true fir, where the moisture content of the wood is very high, the galleries may penetrate to a depth of four or five inches, whereas in Douglas fir the galleries are confined to the sapwood, which varies from one-half to two inches in depth.

Study Procedure

1. Selection and Sawing of Logs

The original intention of this study was to make a detailed examination of approximately 50 infested logs and to make bulk run studies to compare overrun, sawing time and loss in grade for both clean and infested western hemlock and Douglas fir logs. Because the booms contained both logs with very light infestation and clean logs, the bulk run studies proved inconclusive, and the results are not recorded here.

For the special study, logs were carefully selected to give a range of diameters and to show a good cross-section of the severity of the infestation. Thirty-seven logs, ranging in top diameter from 11 to 30 inches, were selected from the boom and bucked into 16-foot lengths. At intervals these logs were sent up the jack ladder into the sawmill. They were numbered and scaled before being cut into heavy cants and heavy slabs at the headsaw. The cants were broken down at the edger into standard sizes for re-sawing and sent to the timber deck where all the pieces from each log were numbered and kept separately. An 8-foot section of slab from each of two opposite faces of the logs was selected to study the frequency of attack and the depth of pentatration of the tunnels. The slabs were cut heavily so that a section could be obtained in which the tunnels could be measured to their greatest depth of penetration.

The lumber from each log was remanufactured into standard sizes on a resaw. At this stage the lumber from each log was tallied and graded by a qualified lumber grader, both as it would have been if free from worm-holes, and as it was with the worm-holes present.

2. Entomological Data

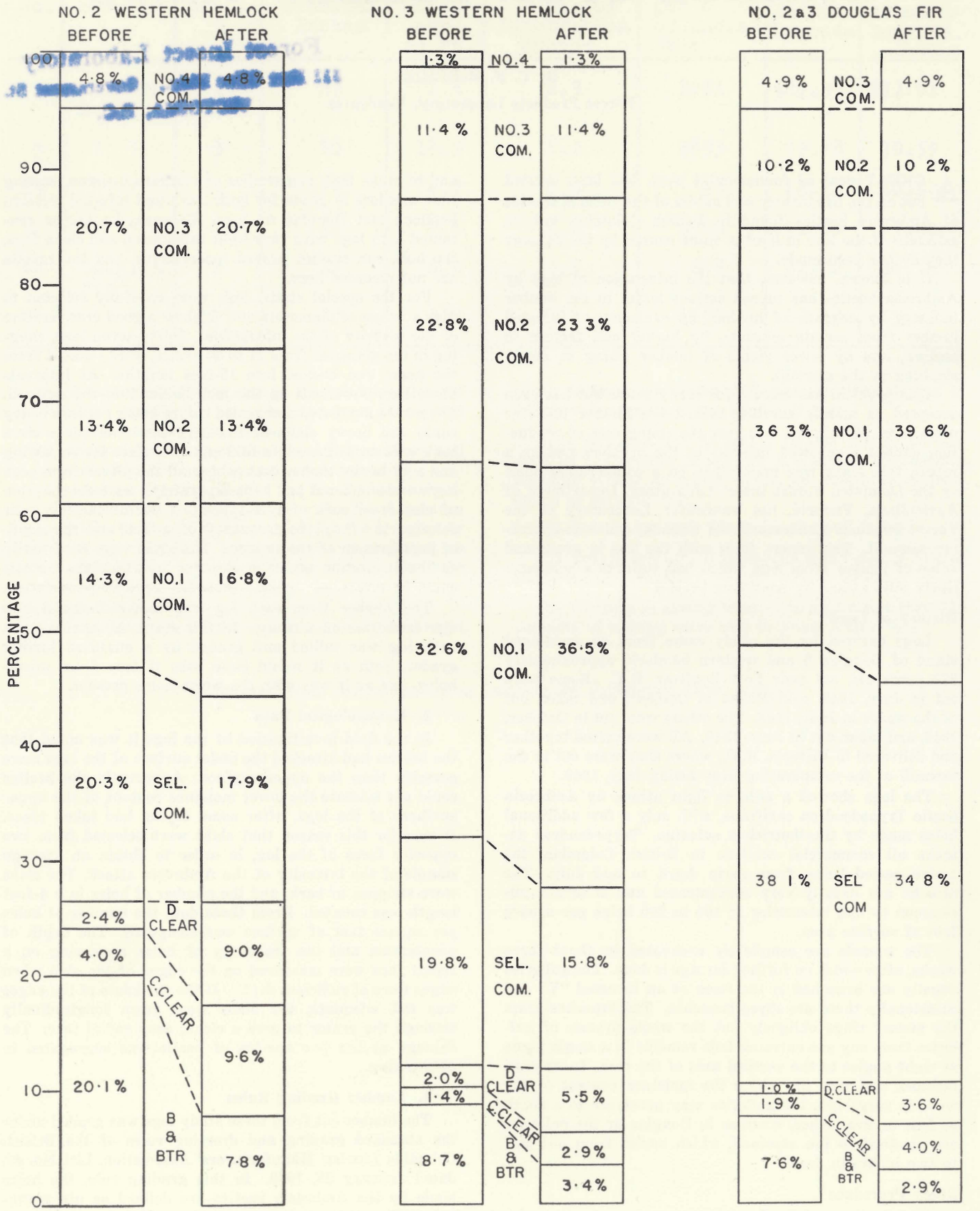
In the field investigation of the logs it was noted that the beetles had attacked the under surface of the logs more severely than the upper surface. Apparently the beetles could not tolerate the lower moisture content of the upper surfaces of the logs, after some drying had taken place. It was for this reason that slabs were selected from two opposite faces of the log, in order to obtain an average sample of the intensity of the Ambrosia attack. The slabs were stripped of bark, and the number of holes in a 4-foot length was counted. From these data the number of holes per square foot of surface was computed. The depth of penetration and the frequency of holes appearing on a radial face were measured on the edges of the slab when edges were of sufficient depth. If the thickness of the edges was not adequate, the slabs were sawn longitudinally through the center to give a clean, deep radial face. The damage of the two species of beetle was segregated in note-taking.

3. Lumber Grading Rules

The lumber cut from these study logs was graded under the standard grading and dressing rules of the British Columbia Lumber Manufacturers' Association, List No. 49, dated January 25, 1949. In this grading rule, the holes made by the Ambrosia beetles are defined as pin worm-holes. For this study, the numbers of holes considered allowable in different grades are as indicated in the following paragraphs.

FIGURE.I

SHOWING PERCENTAGES OF LUMBER GRADES RECOVERED BEFORE AND AFTER DEGRADE



B and Better Clear: No pin worm-holes are allowed in this grade.

C Clear allows "a few scattered" pin worm-holes. This may amount to a maximum of two per square foot of surface, but depends entirely on the appearance of the piece and the combination of other defects.

D Clear grades allow "limited" pin worm-holes. This has been interpreted as a maximum of 20 per square foot, but again the number will depend on the other defects in the piece and will be reduced proportionately to the number of these defects.

Selected Common Dimension does not allow any pin worm-holes.

Selected Common Boards and No. 1 Common Dimension allow "limited" pin worm-holes, that is approximately 25 to 30 holes per square foot, which may be reduced according to the number of other defects in the pieces.

No. 1 Common and lower boards and No. 2 Common and lower dimension allow unlimited pin worm-holes.

From the above interpretation it is very obvious that the degrade from pin worm-holes is greatest in the Clear grades and even a light infestation can cause serious loss in the B and Better and C grades of Clear. In the smaller logs, Select Common Dimension may suffer considerable degrade from a light attack of Ambrosia beetles.

Results of the Study

1. Analysis of Entomological Data

The entomological data assembled during the study have been analyzed thoroughly by Dr. Kenneth Graham, Forest Entomologist, and appear in a separate report. The following is a brief summary of his analysis which gives a measure of the intensity of the beetle attack.

The intensity of attack varied in western hemlock from 1.7 to 31.4 holes per square foot of surface area and in Douglas fir from 1.2 to 22.2 holes per square foot . The damage therefore can be regarded as light to medium.

For the galleries of **Trypodendron cavifrons** a mathematical relationship was found to exist between the number of holes per square foot of surface area of the log and the number of holes appearing per thousand feet of linear radial face. For western hemlock there were 240 holes per thousand linear feet of radial face for each hole per square foot of log surface. For Douglas fir the figure was 220. For example, in western hemlock, if 100 holes were found per square foot of surface, there would be 24,000 holes per thousand linear feet of radial face, or 24 holes per linear foot of radial face.

For western hemlock, the analysis of depth of penetration showed that of the holes appearing on a radial face:

48% were in the outer ½ inch
75% " " " 1 "
91% " " " 1½ "

Very few holes appeared beyond 4½ inches in depth.

For Douglas fir:

80% were in the outer ½ inch
97% " " " 1 "
100% " " " 1½ "

2. Grade Recovery and Value

For favorable boring conditions, the Ambrosia beetle requires wood with a high moisture content. Thus the attack is usually confined to the sapwood in Douglas fir, as the moisture content of the heartwood is normally too low. In western hemlock, where the moisture content of the heartwood is considerably higher than in Douglas fir, the

TABLE I

Total Lumber Volume and Percentages by Grades for the Logs Studied

Grade	No. 2 Western Hemlock				No. 3 Western Hemlock				No. 2 & 3 Douglas Fir			
	Before Degrade		After Degrade		Before Degrade		After Degrade		Before Degrade		After Degrade	
	Vol. ft. b.m.	Per-cent-age	Vol. ft. b.m.	Per-cent-age	Vol. ft. b.m.	Per-cent-age	Vol. ft. b.m.	Per-cent-age	Vol. ft. b.m.	Per-cent-age	Vol. ft. b.m.	Per-cent-age
B	623	20.1	244	7.8	445	8.7	173	3.4	143	7.6	54	2.9
C	123	4.0	298	9.6	73	1.4	146	2.9	36	1.9	76	4.0
D	76	2.4	279	9.0	103	2.0	283	5.5	19	1.0	68	3.6
Sel.	631	20.3	556	17.9	1010	19.8	807	15.8	721	38.1	659	34.8
1 Com.	445	14.3	521	16.8	1665	32.6	1866	36.5	686	36.3	748	39.6
2	417	13.4	417	13.4	1166	22.8	1189	23.3	193	10.2	193	10.2
3	643	20.7	643	20.7	579	11.4	577	11.3	93	4.9	93	4.9
4	150	4.8	150	4.8	66	1.3	66	1.3				
Total	3108	100	3108	100	5107	100	5107	100	1891	100	1891	100
Ave. Value per M	$71.53		$68.22		$59.58		$57.63		$62.49		$61.28	
Percentage not Infested	78.5				77.2				72.0			
Percentage Infested	21.5				22.8				28.0			
Percentage Degraded	14.8				10.0				8.5			

TABLE II

1949-2 Price List

Dollars per M ft. b.m.

Rough Green Clears			
Size	B & Btr.	C Clear	D Clear
1 x 6	$135.00	$130.00	$100.00
1¼ x 6 1½ x 6	143.00	138.00	108.00
2 x 6	138.00	133.00	103.00
2½ x 6 3 x 6 3½ x 6 4 x 6	125.00	120.00	90.00

Rough Green Commons					
Size	Select	1	2	3	4
1 x 8	$55.00	$50.00	$48.00	$40.00	$30.00
1¼ x 8 1½ x 8	60.00	55.00	53.00	45.00	35.00
2 x 6 & 8 18 - 20'	58.00	53.00	50.00	43.00	33.00
2½ x 6 & 8 18 - 20'	63.00	58.00	55.00	48.00	38.00
3, 4 & 6"	64.00	60.00	57.00	50.00	40.00

tunnels may penetrate to 5 or 6 inches. Thus, the damage to the logs is concentrated in the outside portion, from which the clear grades are produced.

Average results for all the logs studied show that approximately 25 per cent of the volume of the lumber produced contained worm-holes, but only 11 per cent was degraded. Of the quantity degraded, 66 per cent was B and Better Clear degraded to C and D Clear, and 30 per cent was Selected Common degraded to No. 1 Common; the remaining 4 per cent included small quantities degraded from C to D Clear, No. 1 Common or No. 2 Common, and from No. 1 Common to No. 2 Common. The greatest percentage degrade and drop in value was found in the No. 2 Grade western hemlock logs.

The logs studied were divided into three groups: No. 2 western hemlock, No. 3 western hemlock, and No. 2 and 3 Douglas fir. Under these divisions, the volume and percentage of grades recovered, together with the average value per thousand ft.b.m., were obtained for the lumber both before and after degrade. Average figures by lumber grades are presented in Table I.

The percentages of lumber volume not infested, infested, and degraded are shown at the bottom of Table I for each of the three groups.

Figure I shows in graphic form the percentages of the various grades of lumber recovered, with the left hand column representing the percentages of the lumber grades before degrade and the right hand column the percentages after degrade.

The sales realization value, or the value per M ft.b.m. of lumber obtained from each log was calculated on the basis of rough green lumber prices. The prices used are shown in Table II and were taken from the Market Survey 49-2 published by the British Columbia Lumber Manufacturers' Association. The sales realization value was calculated by 3-inch diameter classes for each of the three groups of logs, and the results are shown in Table III. The results indicate a decrease in loss of value with increase in diameter, as would be expected, but the sample was so limited that it is felt no definite figures can be given for this trend.

The greatest differences in price are between B and Better Clear and D Clear and between the Clear grades and the Common grades. In this study, the light infestation resulted in the degrade of part of the B and Better Clear to C Clear and very little from the Clear grades to the Common grades. A heavier infestation would have resulted in the degrade of more of the B and Better Clear to D Clear and of more of the Clears to Commons. This condition would have resulted in a very much greater drop in value.

(a) No. 2 Western Hemlock Logs

The eight Grade No. 2 Western hemlock logs yielded a total of 3,108 board feet of lumber. Of this volume 78.5 per cent was without worm-holes, and 21.5 per cent was infested, but only 14.8 per cent of the total volume was degraded because of worm-holes. This resulted in an average loss in value of the lumber of $3.31 per M ft.b.m. or 4.6 per cent of the value.

Twenty per cent of the total lumber volume was B and Better Clear, of which 29 per cent was degraded from B and Better to C Clear and 32 per cent from B and Better to D Clear. In addition, 12 per cent of the Selected Common was degraded to No. 1 Common and 5 per cent of the C Clear to D Clear. Details for Log No. 29 are set out in Table IV. This is a typical example of the loss in grade and value found in the No. 2 western hemlock logs. Of the 29 per cent B and Better Clear found in this log, 73 per cent was degraded to C Clear and 19 per cent to D Clear. Of the 3 per cent C Clear, 43 per cent was degraded to D Clear. Of the 23 per cent of Selected Common, 14 per cent was degraded to No. 1 Common.

(b) No. 3 Western Hemlock Logs

The total lumber volume of the 19 No. 3 grade western hemlock logs was 5,107 board feet. Of this volume 77.2 per cent was not infested, and 22.8 per cent contained worm-holes, but only 10.0 per cent was degraded. This resulted in an average loss in value of the lumber of $1.95 per M ft.b.m., amounting to 3.3 per cent of the value. As in the No. 2 western hemlock, most of the degrade occurred in the B and Better Clear, but showed to some extent in the Selected Common. The logs produced 8.7 per cent of B and Better Clear, of which 26 per cent was degraded to C Clear, and 36 per cent to D Clear. Of the 19.8 per cent Selected Common, 20 per cent was degraded to No. 1 Common.

Table IV shows details of logs No. 5, 23 and 31, which represent examples of heavy and light infestation. Log No. 5 shows the effect of a concentrated attack in which the clear grades have been degraded into the common grades. In this log, all of the C Clear was degraded to No. 2 Common. Log No. 31 shows the effect of complete degrade of all the B and Better Clear, 43 per cent going to C Clear, and 57 per cent to D Clear, while 50 per cent of the Selected Common was dropped to No. 1 Common. Log No. 23 shows small loss in value, owing to very light attack and shallow penetration of the Ambrosia tunnels. In this log 8 per cent of the lumber was B and Better Clear, and 44 per cent of this was degraded to D Clear.

(c) No. 2 and 3 Douglas Fir Logs

There was a total of 1,891 board feet in the 10 grade No. 2 and 3 Douglas fir logs. Of this volume 72 per cent was not infested, and of the 28 per cent infested only 8.5 per cent was degraded by worm-holes. The average loss in value of these logs was $1.20 per M ft.b.m., or 1.9 per cent. This loss is accounted for by a degrade of 34 per cent from B and Better Clear to C Clear, 27 per cent from B and Better Clear to D Clear, and 9 per cent from Selected Common to No. 1 Common. The details for logs No. 44 and 46 are shown in Table IV. Log No. 44 represents very light infestation and shallow penetration and Log No. 46 is representative of a deep penetration in which all the B and Better Clear has been degraded to C or D Clear and 20 per cent of the Selected Common has been degraded to No. 1 Common.

Summary

(1) The study was undertaken as a preliminary step toward appraising the loss in value of lumber due to Ambrosia beetle attack. The Dominion Entomological Laboratory at Victoria, the Forest Products Laboratory at Vancouver, and a co-operating sawmill were responsible for the study.

(2) The logs were felled in July and October, 1948, and taken out of the woods in June, 1949.

(3) A total of 8 No. 2 western hemlock logs, 19 No. 3 western hemlock logs and 10 No. 2 and 3 Douglas fir logs were analyzed in detail.

(4) The intensity of attack varied from 1.7 to 31.4 holes per square foot of surface area for western hemlock, and from 1.2 to 22.2 holes per square foot for Douglas fir.

(5) For western hemlock, the analysis of the depth of penetration shows:

48% of the holes in the outer ½ inch
75% " " " " 1 "
91% " " " " 1½ "
Very few beyond 4½ inches.

TABLE III

Infested Logs

Sales Realization Value Based on Market Survey List 49-2

No. 2 Western Hemlock Logs

Diameter	No. Logs	Before Degrade Value/M	After Degrade Value/M	Difference per M	Percentage of Degrade
*12"	1	$78.50	$69.95	$8.55	12.2
21	3	68.78	66.36	2.42	3.6
24	2	72.70	69.41	3.29	4.7
30	2	70.99	68.96	2.03	2.9
Weighted Average	8	71.53	68.22	3.31	4.6

No. 3 Western Hemlock Logs

Diameter	No. Logs	Before Degrade Value/M	After Degrade Value/M	Difference per M	Percentage of Degrade
12"	3	$58.86	$56.94	$1.92	3.4
15	2	59.28	55.86	3.42	6.1
18	6	56.06	54.50	1.56	2.9
21	3	61.38	58.44	2.94	5.0
24	4	62.58	61.30	1.28	2.1
30	1	66.03	64.87	1.16	1.8
Weighted Average	19	59.58	57.63	1.95	3.3

No. 2 & 3 Douglas Fir Logs

Diameter	No. Logs	Before Degrade Value/M	After Degrade Value/M	Difference per M	Percentage of Degrade
12"	2	$66.30	$64.34	$1.96	3.0
15	3	63.50	62.43	1.07	1.7
18	5	60.35	59.37	.98	1.7
Weighted Average	10	62.49	61.28	1.21	1.9

*This log yielded such a high percentage of clears that it was put in with the No. 2 logs.

TABLE IV

Showing Relation of Number and Depth of Ambrosia Beetle Holes to Lumber Value

Log No.	Species	Log Grade	Top Diameter Inches	No. Holes per sq.ft.	Maximum Depth of Penetration Inches	No. Holes per M ft. of Radial Face	Value/M ft. b.m.	
							Before Degrade	After Degrade
29	Western hemlock	2	23	11.4	2.3	3931	$80.32	$77.01
5	" "	3	20	18.5	2.7	3833	79.18	70.59
23	" "	3	17	4.7	0.6	93	62.11	60.93
31	" "	3	15	9.6	1.8	3916	71.69	63.61
44	Douglas fir	2	17	6.2	0.5	625	61.20	60.49
46	" "	2	17	4.9	1.2	1559	62.14	59.23

(6) Results show 25 per cent of the volume of lumber cut contained worm-holes, but only 11 per cent of the total volume was degraded on this account.

(7) Sixty-six per cent of the B and Better Clear, and 30 per cent of the Selected Common, was degraded.

(8) Average loss in value for the No. 2 western hemlock logs was $3.31 per thousand, for the No. 3 western hemlock logs $1.95 per M ft.b.m., and for the Douglas fir logs $1.21 per M ft.b.m. Lumber prices were based on Market Survey 49-2 published by the British Columbia Lumber Manufacturers' Association.

Conclusion

The results shown in this report indicate that a light attack of Ambrosia beetles will cause considerable loss in lumber value for the better grades of logs.

It is felt that the foregoing figures justify further study on this project. In addition to a more comprehensive sampling of loss in lumber grade, the following subjects should be investigated:

(1) Loss in log scale due to heavier cull factor.

(2) Loss in overrun. It is possible that owing to heavier slabbing and edging, the overrun may be lower.

(3) Increase in sawing time—this may result from the necessity of making extra cuts to obtain a clear face.

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