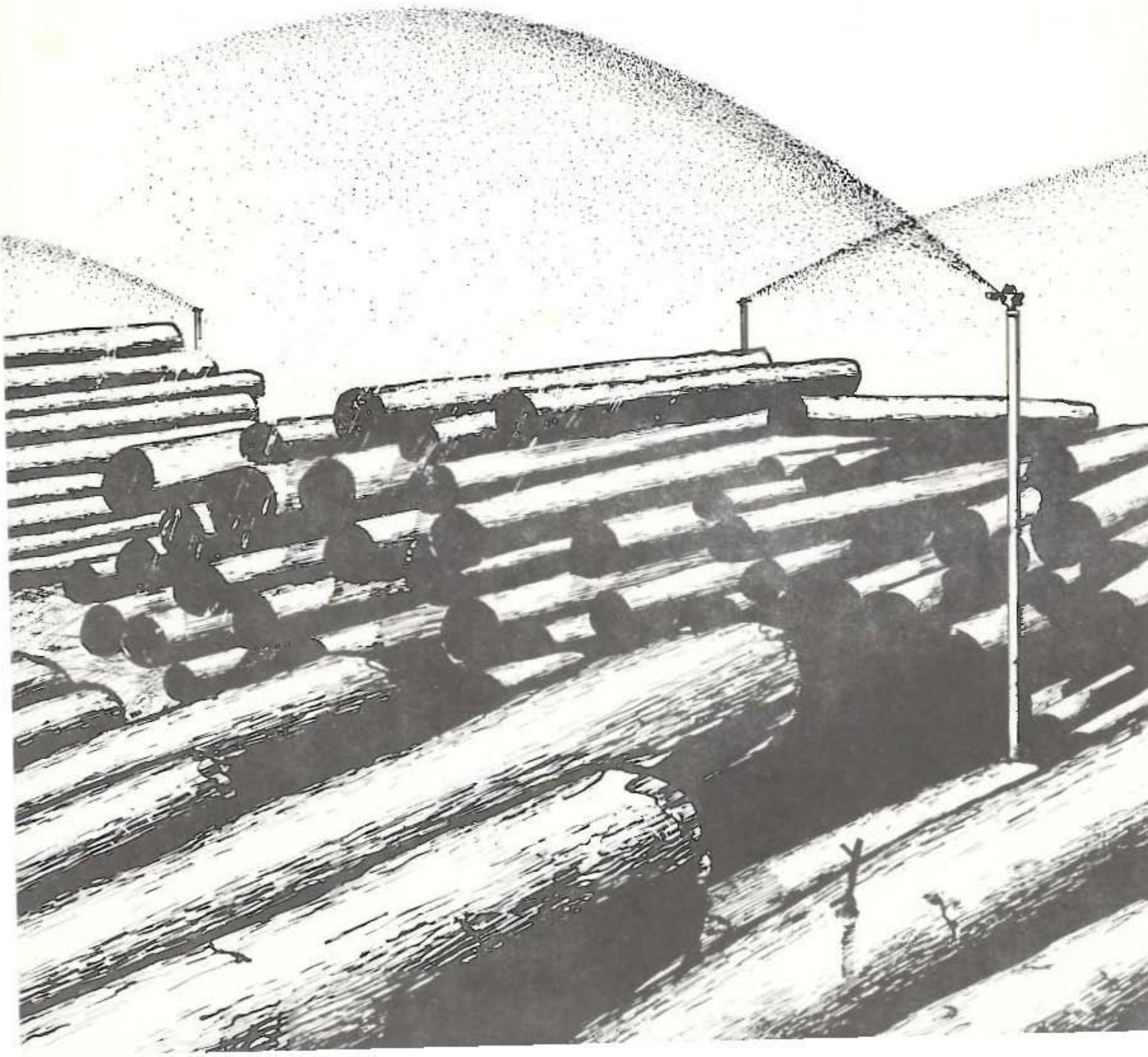
Water Misting For Log Protection

FROM AMBROSIA BEETLES IN B.C.

H.A. Richmond W.W. Nijholt

A cooperative project by
B.C. Forest Products Ltd
Council of the Forest Industries
Canadian Forestry Service



WATER MISTING FOR LOG PROTECTION FROM AMBROSIA BEETLES IN BRITISH COLUMBIA

GENERAL INTRODUCTION

Ambrosia beetles have long been a problem in coastal British Columbia. Climate, extensive stands of mature coniferous forests and methods of harvesting them all favor these insects. Logging debris and stumps provide good beetle breeding sites, as do right-of-way logs and other timber left too long after felling. One species, *Trypodendron lineatum* (Oliv.), which attacks all commercial softwood species in this area, is by far the most abundant and damaging. Densities of 50 to 100 entrance holes per square foot of log surface are not unusual. The beetles burrow into the sapwood, resulting in degradation of lumber and plywood. Furthermore, the export of beetle-damaged lumber to certain overseas markets is restricted because of the possibility of accidental introduction of these insects.

Research on biology and control of *Trypodendron*, and on the economic losses it causes, has been carried out over many years in this region (1-10, 12-14). Its attack flights occur in spring, from April through June, depending on when the weather warms sufficiently. Logs felled during spring are relatively immune to attack; those felled the previous autumn and winter are preferred by the beetles.

Prevention of beetle damage by insecticide application is not economically feasible unless the logs are in water, where treatment can be applied effectively from the air. During recent years, helicopter spraying of boomed logs in water storage has provided economic control. But although current logging is cleaner and faster, resulting in less breeding material and less damage to logs in the woods, a serious problem remains at times and under some conditions, particularly at dry-land log sorting and storage areas. There is increasing public concern over insecticides, and the effective but persistent lindane, which protected logs from ambrosia beetles in the past, is not now being used. This, and public health restrictions on other insecticides where domestic water supplies may be contaminated, has intensified the search for alternative ways to reduce log damage by these insects.

Water sprinkling has been found to reduce deterioration of stored logs (11, for example) and was recently tested in British Columbia (15). Discussions of the Pest Control Committee of the Council of the Forest Industries of British Columbia led to a cooperative project to test the cost and effectiveness of water spray for preventing ambrosia beetle damage to logs in dry-land storage.

Part I. Test design and operation

H. A. Richmond, Entomologist, Council of the Forest Industries of British Columbia.

INTRODUCTION

The use of water sprinklers to protect logs from attack of wood borers was first undertaken in British Columbia by Roff and Dobie (15) at Williams Lake in 1968. Their study was concerned with the overall biological deterioration, including decay and checking, as well as insect attack. Water application prevented insect attack except where coverage was poor. Some companies on Vancouver Island have tried to protect logs from ambrosia beetles by using agricultural sprinklers on the tops of log decks. However, the results have not been satisfactory on the sides of log piles where some butt ends lacked the protection of water and were exposed to attack.

In this test, an attempt was made to protect dry-land sorted logs from attack of ambrosia beetles by an installation designed to wet all log surface areas in the piled logs. The system has not been tested on water-stored logs or log booms, and does not necessarily replace protection with chemicals under certain conditions of water storage.

Because dry-land sorting on the British Columbia coast involves heavy investment and operates year-round, a permanent sprinkling system should be designed. It should be possible to turn it on and off as required, and to add or remove logs from the treated area without dismantling or interrupting the sprinkling equipment.

To meet these requirements, and considering the habits of the ambrosia beetle, a system was designed to produce a continuous mist of water from ground level to the top of the log deck and to surround the sides, ends and tops of the pile with the mist. By applying water in this fashion, it was thought that all surface areas of logs would become soaked, particularly the butt ends -- normally subject to heavy beetle attack -- projecting unevenly from the piles. It was speculated that such a mist of water would prevent beetle flight into the test area.

PILOT MODEL

A pilot model of the hydraulic system was tested in 1970, on the dry-land sorting grounds of MacMillan and Bloedel Limited, at Northwest Bay, Vancouver Island. At that time, its biological effectiveness could not be determined but, from its design and operation, an improved system was developed in 1971.

OPERATIONAL SYSTEM

An operational system was installed on the dry-land sorting grounds of B.C. Forest Products Limited, at Port Renfrew, Vancouver Island, in 1971. This area was selected because of its large known population of ambrosia beetles and because of the interest of the company in such a development. The company not only provided daily surveillance of the operation throughout the summer, but shared the cost of installation, operation, and provision and movement of necessary logs for the test.

To be sure no interruption occurred during the test, water was applied 24 hours a day, 7 days a week for 148 consecutive days, from April 3 to August 27, 1971.

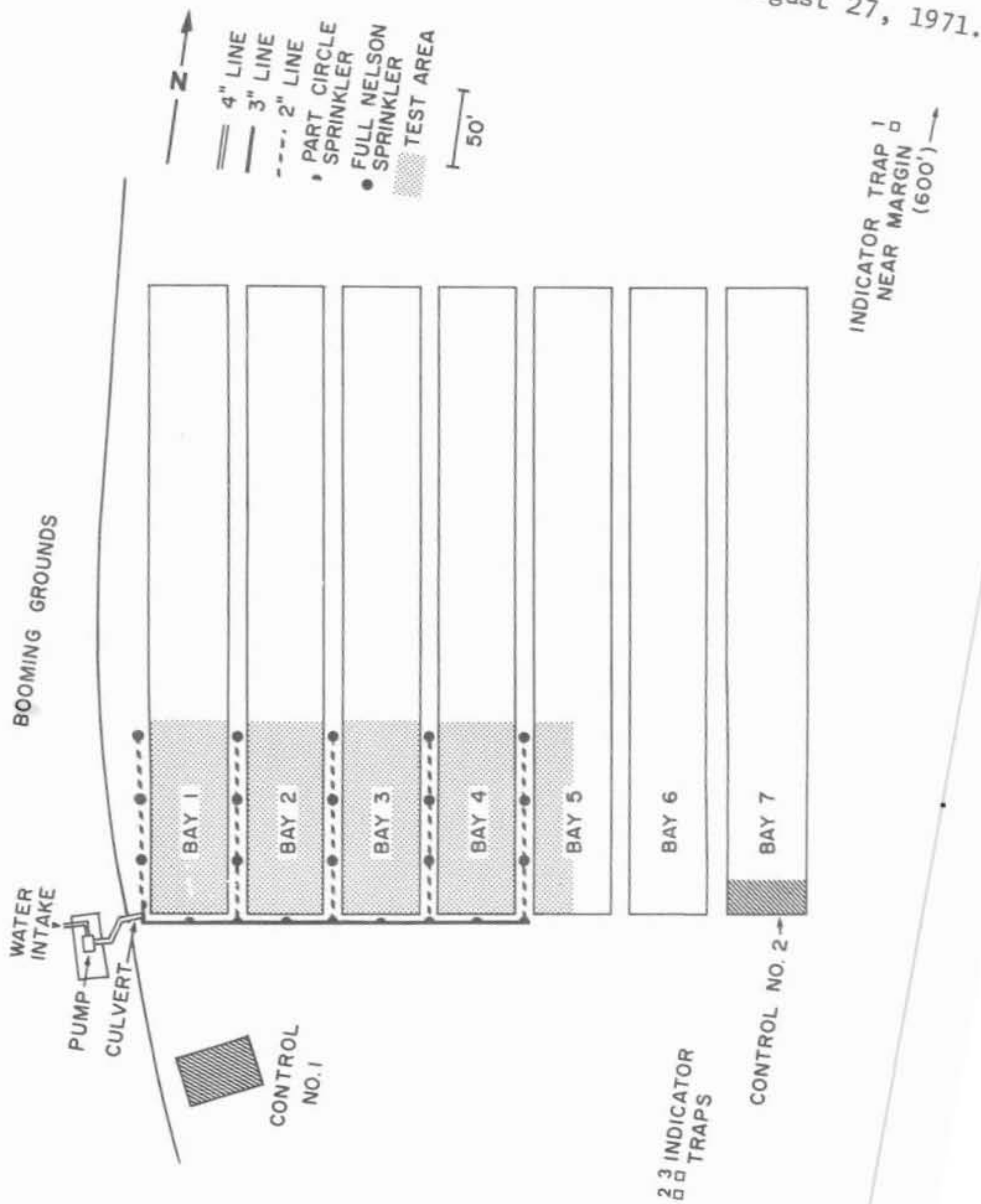


Figure 1. Diagram shows arrangement of test logs, water

DESCRIPTION OF SITE

The dry-land sorting grounds at Port Renfrew cover approximately ten acres. Within this site, one area is designed for log storage over indefinite periods. During this period of storage, the most severe beetle attack occurs and some form of protection is required.

Logs are usually stored in bays, each 300 feet long, spaced to accommodate 40-ft logs and to allow 15 to 20 feet between each bay (Figure 1). The test was conducted on 125 feet of each of four bays and also included Bay 5, which was sprinkled on one side from Bay 4. In addition to the sprayed logs, there were untreated checks: one pile of 60 logs near Bay 1, and a group of 40 logs at Bay 7. Other checks are outlined in Part II.

DESIGN OF HYDRAULIC SYSTEM

The installation was of a temporary type; i.e., aluminum tubing with ring-and-lock self-sealing connectors. It was intended, should the system prove effective, that a permanent underground installation of high-pressure plastic piping would be recommended. Such an installation with submerged self-sealing connectors for the nozzles and risers would permit ready installation or removal as desired, and normal work operations could be carried on over the area without disrupting the equipment.

Although the general design was developed from the 1970 pilot test, detailed specifications for the operational system were formulated by M. Pohlman, Hydraulic Engineer. Mist production requires a higher pressure and different nozzles than those generally used for irrigation. It was considered important to have professional advice in planning the system, as pump, line capacity, pressures and volumes had to be selected and matched carefully to attain the objective.

Figure 2. View between log bays shows arrangement of water lines, risers and sprinklers. Note nearby forest, source of attacking beetles.

The mainline from the pump was three-inch aluminum irrigation piping, extending 320 feet. Off the mainline were two-inch aluminum laterals which passed midway between each bay at ground level. A shut-off valve was installed at each lateral connection with the mainline to avoid disrupting the entire operation if it became necessary to shut off a lateral. Along the laterals, at 40-foot intervals, were 15-foot risers accommodating misting nozzles. The risers, one-inch galvanized piping, were supported in an upright position with a metal tripod. Risers were also installed along the mainline, at each junction of the lateral, and midway between each lateral (Figures 1, 2).

Figure 3. Pump on float, showing two flexible connections to allow for tidal movement.

The pump was installed on a float in an inlet, and to allow for the rise and fall of tides, a four-inch pressure hose was used to provide a flexible discharge line (Figure 3). One replacement of the discharge hose was required during the summer.

PUMP AND SPRINKLER SPECIFICATIONS

Sprinklers from risers on the lateral lines were full-circle 50-foot radius, Nelson No. F. 32-1/8-inch, making three revolutions per minute delivering 4.09 gpm at 80 psi; precipitation rate was 0.85 inch per hour. Sprinklers from risers along the mainline were Rainbird, part-circle 50-foot radius, No. 25ASP - 3/32-inch, delivering 2.4 gpm at 80 psi; precipitation rate was 0.65 inch per hour.

Figure 4. Log decks being sprayed, showing mist created by high pressure system.

Water requirement of this system, using 15 Nelson and nine Rainbird sprinklers, was 83 gallons per minute or 4,980 gallons per hour. These nozzles produced a combination of large and small water droplets and drifting mist (Figure 4).

Pump requirements for this volume and pressure were 252 TDH (Total Dynamic Head) or 110 psi at 146 gpm. To fulfill this requirement, the pump selected was: Ajax 1½ L; 20 hp; 3600 rpm; 3 phase; 60 cycle; 230-460 volts, equipped with stainless steel shaft to prevent sea-water deterioration. Weight of the pump was 450 pounds.

OPERATION DETAIL

The system operated 24 hours a day, with a pressure of 90 psi, measured at the most remote sprinkler. Salt water from an inlet was used because of the shortage of fresh water. An agricultural irrigation cylindrical sieve of 40 holes per-square-inch was installed at the intake, supplemented with a finer nylon screen that fulfilled all the requirements of the Department of Fisheries and kept debris out of the system.

Although questions arose as to whether the sprinklers would withstand the unusually high pressure on a 24-hour operational basis, no trouble was experienced with them during the test period.

Since the hours of mass flight of ambrosia beetles during attack periods cannot be predicted, the system was operated without interruption over the possible beetle flight period. Wet bark appears to be the key to log protection. Since the hard-to-reach butt ends of logs were wetted only through the drifting water mist, it was decided not to turn off the system at night or during cool weather, even though beetles do not fly then.

CORROSION

The problem of salt-water corrosion caused considerable concern in the initial planning. After five months of continuous operation, the pump showed no corrosion, due to its construction and the use of stainless steel. Corrosion was most evident on the sprinkler heads, which would not be re-usable, on the cast aluminum coupler take-off elbows, and in the steel parts used in the flow-control valves (springs and pins). This was not unexpected since, with dissimilar metals such as steel and aluminum in association with salt water, some deterioration was inevitable. On the aluminum tubing, corrosion was only moderate, but it was greater on rings and latches of the couplers, which were not entirely aluminum. If fresh water were used, corrosion would cause little or no problem.

COSTS

Costs of a similar installation would vary with local requirements such as extension of power lines, installation of pump house, drainage, etc.

The experimental system used in this test was of a temporary nature, and consisted of aluminum irrigation piping above ground. The costs were:

Planning		$ 184
Capital		
Piping, couplers, risers, sprinklers, etc.	2409	
Electrical pump, 20 hp	976	
		3385
Operation		
Setting up equipment	231	
Dismantling equipment	146	
Maintenance	325	
Power	1044	
		1746
Total Cost		$5315

A permanent installation, as envisaged, would consist of high-pressure plastic piping installed underground, with proper drainage provided and a permanent pump house. The estimated cost for such an installation is approximately $6,000.

BENEFITS

The scaled volumes of the treated portions of Bays 1, 2 and 3 were 270, 198 and 252 cunits (Ccf.), respectively, totalling 720 cunits or approximately 432 thousand board feet. A heavy attack on these logs, as is usual in this area, could result in serious degrade losses, depending on the size and grade of log affected. The most recent calculations on degrade losses on high-grade hemlock sawlogs, using export prices, range as high as $25 per MBM ($15 Ccf). On this basis, losses could have reached as high as $10,000. Probable losses, however, on the basis of average grades at this sorting ground, are estimated at about $5,000.

Assuming that the capital cost is written off in a five-year period, with an annual operational cost of $1,400, we have an annual cost of some $1,480, or about $2 per Ccf.

The capacity of this installation, however, is for much larger coverage than that sprayed in the Port Renfrew test. Since operational costs would be little changed, the system is capable of considerable expansion with a reduced cost per unit of treated log volume.

DISCUSSION

The system was totally effective, as supported by the assessment of the Canadian Forestry Service. While beetles were found crawling on wet logs, none attempted entry.

It would appear that the key to success is the location of the risers and sprinklers between the decks rather than being mounted on the top, and the use of water mist rather than drenching spray, as used in the agricultural irrigation which requires more water. It was thus possible for water to reach those butt ends of logs projecting unevenly from the piles which would normally remain relatively dry if ordinary sprinklers were installed on top of the log bays.

The use of water, as described, has proven an effective and practical method for protection of stored logs from attack of ambrosia beetles. To be effective, however, an installation involves design considerations that require sound technical advice. It is recommended that before any company becomes involved in expenditures of this nature, the proposal should be discussed with the Council of the Forest Industries, Vancouver, where advice can be obtained.

Part II. Biological assessment

W. W. Nijholt, Pacific Forest Research Centre, Department of the Environment.

INTRODUCTION

The Canadian Forestry Service evaluated the effectiveness of the Council of the Forest Industries of B.C. water misting test described in Part I.

Log decks used in this experiment were made from unscaled timber felled at two sites near Port Renfrew during October and November 1970. Some logs from the same sources were used as controls (Figure 5). One pile of 60 control logs was placed near Bay 1 and another of 40 logs, 200 ft east of Bay 4 (Figure 1). All logs were in place by the middle of March and the misting started the first week of April 1971.

The area surrounding the log storage site, particularly the forest margin to the north, was known from previous sampling to have a large population of overwintering ambrosia beetles, *Trypodendron lineatum* (Oliv.).

Figure 5. Unsprayed logs used for test controls.

BIOLOGICAL ASSESSMENT

Monitoring of beetle flight

Sources of strong odor attraction for beetles were set up by adding female beetles to logs in screened cages (Figure 6), as described in (2). Glass barrier traps were used to sample responding beetles, to obtain an indication of flight periods and relative flight intensity near the northern margin as well as near the test area. These indicator traps were located as shown in Figure 1. Traps were also placed at various positions on control and test log piles and at the ends of some logs facing the ditch between Bays 2 and 3.

Figure 6. Indicator trap: attractive log enclosed in plastic cage with traps at screened top, for monitoring beetle flight periods.

Appraisal of beetle attack on wet and control logs

Observations were made frequently during periods of beetle flight to obtain information on the behavior and activity of the beetles in and around the wet decks, and on the formation of boring dust piles from successful attacks. Logs from the upper, middle and lower layers in three of the test decks were selected at random and marked to indicate the position of their top surface. At the end of the test, the marked logs were spread on the ground in a random position with reference to the original top surface (Figure 7). Debarked square-foot sections along the top of these logs were examined for ambrosia beetle holes. All control logs were examined in a similar manner, except those that were old when cut or badly damaged.

Figure 7. Logs arranged for examination, with marked original orientation of upper surface. Surface mold growth shows on ends of logs.

Appraisal of beetle attack on billets

Twenty 30-inch billets cut from Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, felled in December 1970, were placed between the logs of test Bays 2 and 3, at various heights. A similar group was added to control pile 1. At the end of the test, each billet was debarked and examined for ambrosia beetle holes.

Precipitation measurements

Some measurements of amounts of spray falling on logs were made, using 3-inch i.d. jars. In the first test, 15 jars were set out along the line connecting the sprinklers between Bays 2 and 3, for 30- and 60-minute periods. A second series of measurements was taken on logs of Bay 5. Five jars were placed at 3-ft intervals on a log in line with a sprinkler head and another set in between two sprinkler heads, for 60 minutes.

RESULTS AND DISCUSSION

Monitoring of beetle flight

The first flight commenced in mid-April when air temperature at Port Renfrew rose above 60 F for a short time. Toward the end of April, a few days of hot weather occurred during which large numbers of beetles were caught in the traps, indicating a heavy flight. Intermittent flight activity continued during warm days until May 11. There was no flight most days during the period beginning then, as weather was generally cool and rainy. Daily maximum and minimum temperatures during the test period and beetle catches at the indicator trap near the northern margin are presented in Figure 8. Of note is the variability of temperature from the end of April to mid-May. On April 25, the temperature rose sharply to about 70 F and the major flight of the season took place the following day. After this period of flight, there was a long, cool interval with little or no flight. The flight period was essentially over by early July. Observations on April 25 showed many different insects flying toward and through the water mist. Extensive examination of the wet logs then revealed ambrosia and bark beetles crawling on the bark. As many as 10 per square foot were seen at times.

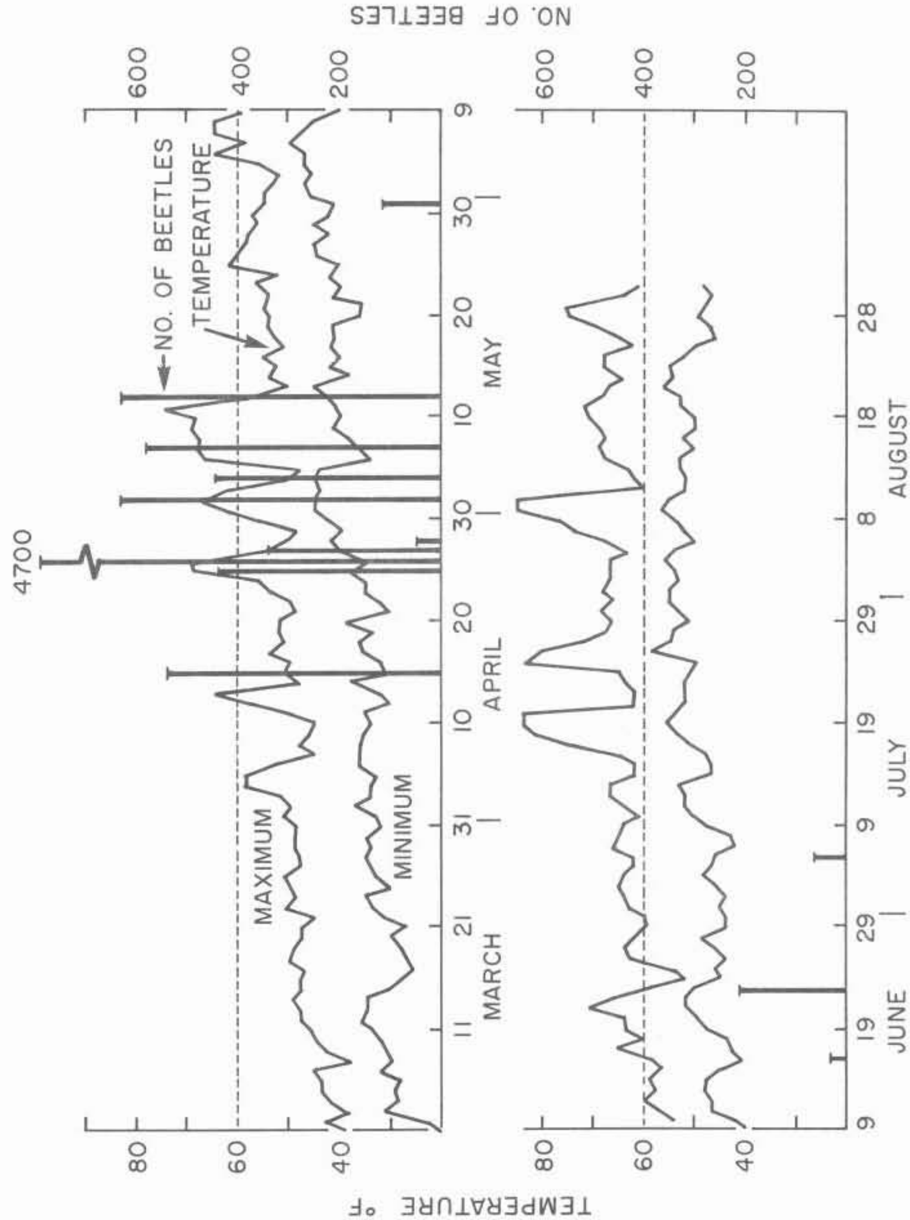


Figure 8. Daily temperatures through flight period, and numbers of beetles collected from flight indicator trap near north margin of log storage area.

Although the wetness of the logs hardly impeded the searching movements of the beetles, none was seen burrowing into the bark. They halted when hit directly by water drops but, after drying and wiping their antennae with their forelegs, started crawling again. They avoided crevices filled with water. Some attempted to fly but had difficulty taking off because their wings stuck on the wet bark.

The indicator trap catches (Table I) show that many more beetles were caught near the northern forest margin than near the test area. Sampling in that margin in recent years revealed large numbers of overwintering beetles; therefore, it was expected that more beetles would be caught there. Also, a large volume of unprotected log material was in competition with sources of attraction near the test and control logs at the opposite side of the sorting and storage area.

<u>Appraisal of beetle damage on wet and control logs</u>

Half the width of a fifth bay beside the sprayed decks was wetted by spray from the adjacent sprinklers so that each log was wet at one end and dry at the other (Figure 9). This provided an ideal test of the protective effect of the water. Ten logs from the upper layer showing beetle-dust piles at the dry ends, were sampled by counting beetle holes in square-foot samples near each end.

The results (Table II) clearly indicate that wetting of these logs prevented beetle damage. The depth of penetration on the dry ends was about $1\frac{1}{4}$ inches. Log 10 was farthest from a sprinkler and its coverage by water varied with the wind. Its surface at the time of sampling was just moist.

Figure 9. Log bay No. 5 partially wet (left side) from bay No. 4 spray. Comparisons were made of beetle attacks on wet and dry ends of the same logs.

One partially sprayed log in Bay 5 was sampled at 1-ft intervals, starting 3 ft from the end, and a gradient showed in the number of attacks:

Distance in ft from dry end	3	5	7	9	11	13	15	17	19	20	21	23
Number of beetle holes/sq. ft.	18	20	18	18	10	15	8	7	9	3	0	0

The sample at 21 ft was about 30 ft from the spray nozzles between Bays 4 and 5. More intensive sampling was carried out on a dozen logs from the layer below the top of Bay 5.

These logs were sampled (wet and dry ends, respectively) on the four quadrants within 8 ft from each end (Table III). At the dry ends, a total of 116 holes was found in 41 sq ft. The wet ends had no holes in 42 sq ft. Not all samples could be obtained from logs 9-12 because of splitting and breakage. Although the number of attacks on the dry ends was small, the results show that wetting of the logs provided complete protection against beetle attack. The results from sampling test and control bay logs on three dates are shown in Table IV (Figure 10).

Figure 10. Logs with square-foot pieces of bark removed for beetle attack counts.

Only a few logs of the control piles were suitable as checks. Several were old, showing beetle damage received in previous years, or were too badly damaged on the surface for sampling. In assessing the effectiveness of future operations of this kind, it is important to ascertain that check logs have not been attacked previously, as this might lead to erroneous conclusions.

The light density of attacks on these control logs, relative to densities often found, may be due to their susceptibility as well as their position in the test storage area.

During the continued application of water, the test logs developed conspicuous slimy fungus growths on the butt ends and on the bark surface (Figures 7, 11) but these did not penetrate the logs or affect their quality.

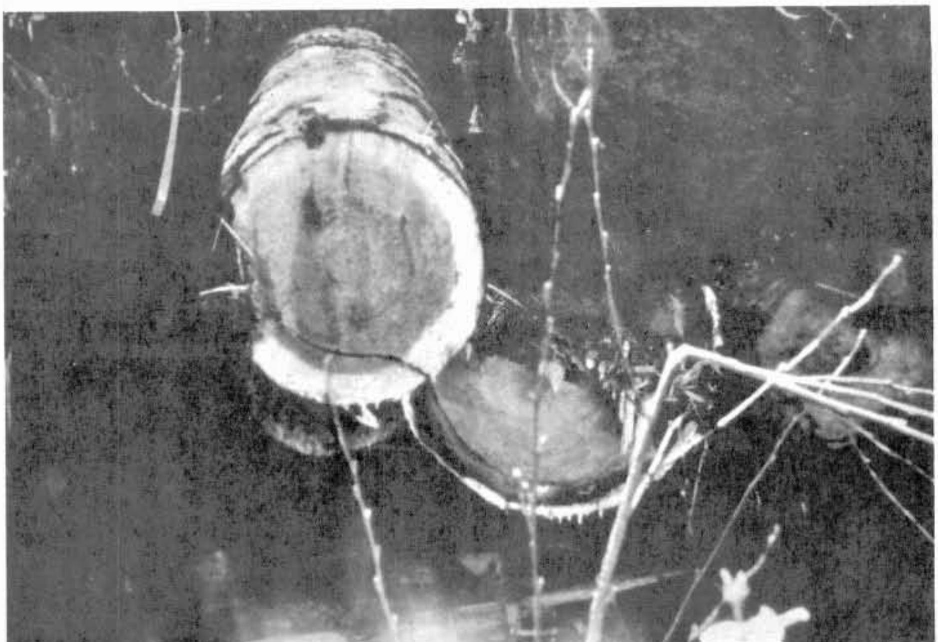


Figure 11. Close-up of surface mold and slime growth on wet logs. This growth does not penetrate into the wood or affect log values.

Appraisal of beetle damage on billets

The 20 billets placed among the logs of Bays 2 and 3 were removed and debarked on June 18. Three short galleries were found in one billet from the northern end of the sprayed zone of Bay 3, but no holes were found in any other wet billets. Of the billets placed in control pile 1, the number of entrance holes was counted in 13, the average number of holes per sq ft being 8.4 (Table V). The other control billets were used for interim checks during the test period.

Measurements of water applied

The results obtained in the two measurements (Tables VI and VII) indicate considerable variability in amounts of water. This was expected as spray fall-out was strongly influenced by wind speed and direction. However, throughout the test period, all treated logs appeared thoroughly wet and even portions that received less water during windy periods remained free from attack.

CONCLUSIONS

Based on many direct observations during the test and the data presented in this report, the water misting system was totally effective in protecting stored logs from damage by ambrosia beetles. Water coverage, though influenced by wind, was sufficient to prevent beetles that landed on the logs from entering. Logs in the lower layers of the decks were wetted by dripping from the upper logs and by wind-blown mist that penetrated the log piles.

TABLE I

Numbers of ambrosia beetles, _Trypodendron lineatum_ (Oliv.), caught at indicator cages with attractive logs

Date	Trap 1 (near margin)	Trap 2	Trap 3
April 15	535	-	-
25	442	70	15
26	4700	348	110
27	338	171	45
28	53	18	12
May 2	635	170	45
4	447	210	92
7	586	366	119
12	630	372	62
31	120	36	9
June 9	0	14	2
16	26	22	5
23	210	23	23
July 6	67	11	8
Total	8789	1831	547
Grand Total	11167		

TABLE II

Ambrosia beetle attacks on logs of Bay 5, sprayed only on one end

Log No.*	No. holes per square feet	
	Dry end	Wet end
1	8	0
2	18	0
3	20	0
(15 ft from end)	7	
4 (5 ft from end)	26	0
5	6	0
6	21	0
7	4	0
8	16	0
9	10	0
10	3	6

* Samples taken 3 ft from either end, unless otherwise indicated.

TABLE III

Ambrosia attacks in samples selected at random within
8 ft from each end of logs wet only on one end

	Wet end				Dry end			
Quadrant	I*	II	III	IV	I	II	III	IV
Log No.	holes per sq ft				holes per sq ft			
1	0	0	0	0	0	0	0	0
2	0	0	0	0	1	6	2	0
3	0	0	0	0	4	0	2	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	3	0	0	1
6	0	0	0	0	0	9	5	1
7	0	0	0	0	4	11	5	5
8	0	0	0	0	0	7	4	8
9	0	0	-	-	2	16	-	-
10	-	-	0	-	-	-	0	-
11	-	0	0	0	-	11	5	2
12	0	0	0	0	0	-	0	2
Total holes	0	0	0	0	14	60	23	19
Avg holes/ sq ft	0	0	0	0	1.4	6.0	2.3	1.9

* I, II top of log; III, IV bottom of log

TABLE IV

Results of sampling for beetle attacks on sprayed logs and dry control logs

TEST LOGS

Date	Bay No.	No. of sq ft areas examined No. of logs in brackets	Number of holes found
June 16	3	234 (39)	0
July 16	2	189 (40)	0
Aug. 27	1	130 (28)	0
Total		553 (107)	0

CONTROL LOGS

Date	Pile No.	No. of sq ft areas examined No. of logs in brackets	Number of holes found
June 22	2	62 (14)	403
Sept 13	1	67 (17)	128
Total		129 (31)	531

Avg No. of holes/sq ft - 4.1

TABLE V

Ambrosia beetle attacks on 30-inch billets from control pile 1 (dry) and from test Bays 2 and 3 (wet)

Control billet No.	No. of holes per billet	No. of holes per sq ft
1	29	5.7
2	56	8.2
3	14	2.9
4	113	15.7
5	29	5.1
6	57	10.9
7	92	15.2
8	17	3.4
9	24	3.6
10	69	10.9
11	67	11.8
12	28	5.2
13	50	7.6
Total no. of holes	645	

Total area examined - 76.65 sq ft

Avg - 8.4 holes/sq ft

TABLE VI

Water precipitation measurements during 30 min (Test 1) and 60 min (Tests 2 and 3) periods. The values represent the precipitation at ground level between Bays 2 and 3, at about 10-ft intervals

Jar #	Test 1 mm/hr	Test 2 mm/hr	Test 3 mm/hr
1	3.6	2.2	1.2*
2	6.4	4.1	5.7
3	3.1	6.3	7.0
4	1.8	4.8	3.3*
5	3.8	3.0	2.1
6	4.0	2.1	4.2
7	2.0	3.6	5.5
8	2.4	5.6	2.5*
9	3.8	20.4**	1.8
10	5.4	2.6	3.6
11	3.2	2.5	5.3
12	2.3	4.3	3.9
13	1.6	4.3	1.8*
14	4.0	2.1	1.9
15	2.5	1.8	2.2
Avg	3.3 (3.2 in/ 24 hr)	3.5** (3.4 in/ 24 hr)	3.5 (3.4 in/ 24 hr)

* jars placed directly under risers

** disregarding jar #9, leaking connector

TABLE VII

Water precipitation measurements for 60 min. on top of Bay 5 logs, at 3-ft intervals from the centre line between Bays 4 and 5

	Between sprinklers		Even with sprinklers	
Dist. in ft	Test 1 mm/hr	Test 2 mm/hr	Test 1 mm/hr	Test 2 mm/hr
20	2.9	2.8	4.0	3.6
23	2.0	1.9	3.9	3.3
26	1.4	1.9	2.9	2.8
29	0.8	0.8	1.9	2.1
32	0.4	0.4	1.3	1.4

ACKNOWLEDGMENTS

The test was a cooperative project involving several organizations. The Council of the Forest Industries of British Columbia assumed much of the cost. H. A. Richmond, representing the Council, coordinated the planning and design of a preliminary pilot test, as well as the operational test. M. Pohlman, B. A. Chemical Ltd. Vancouver, designed the hydraulic system and gave technical advice. British Columbia Forest Products Ltd. made their dry-land sorting area at Port Renfrew available for the test, provided the logs, supervised the installation and maintenance of the hydraulic system and shared the cost of the equipment. K. A. Hallberg, Logging Superintendent cooperated in every way, and J. S. Nichols, W. Coombs and B. Seigler assumed responsibilities for the test on behalf of the company. The Canadian Forestry Service provided advice during the planning of the test, through J. W. Roff and J. Chapman, and made the biological assessment of its effectiveness. This was done by W. W. Nijholt, who made repeated observations during beetle flights, set up and serviced the monitor traps and test billets and did the final sampling of logs for beetle attacks, with some assistance from S. Ilnytzky.

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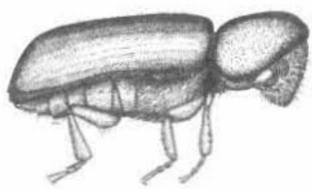

AMBROSIA BEETLE *Trypodendron lineatum*