U. S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
R. W. COWLIN, DIRECTOR

Research Note

Number 177 Portland, Oregon December 1959

SPRINKLING TO PREVENT DECAY IN DECKED WESTERN HEMLOCK LOGS

by

Ernest Wright, A. C. Knauss, and R. M. Lindgren[1/]

Decay developing in decked western hemlock (Tsuga heterophylla) has caused considerable loss in pulp yields in the Pacific Northwest. The Oregon Pulp and Paper Co., which commonly decks hemlock logs through one summer and occasionally through two summers, cooperated with the Pacific Northwest Forest and Range Experiment Station in a study to determine (1) how much decay and pulp yield loss would develop during 1 and 2 years of storage and (2) whether the amount of such decay and loss could be decreased by continuous sprinkling with water during the dry summer months.

In the study, the volume of decay in 160 logs was measured before storing them in water-sprinkled and unsprinkled decks and again after 1 and 2 years of storage. During 1 year of storage, not enough decay developed in either deck to reduce pulp yield; but after 2 years, a significant amount of decay had developed in the unsprinkled deck and pulp yield was decreased. Temperature measurements during storage showed that sprinkling did not cool logs sufficiently to inhibit decay. At the end of the study, however, moisture content of the sprinkled logs was found to be well above that of the unsprinkled logs, and this is believed responsible for inhibiting decay.

1/ Respectively: Pathologist, Oregon Forest Lands Research Center, Corvallis, Oreg. (formerly Forest Pathologist, Pacific Northwest Forest and Range Experiment Station); Wood Technologist, Pacific Northwest Forest and Range Experiment Station; and Chief, Division of Wood Preservation, Forest Products Laboratory, U.S. Forest Service, Madison, Wis.

Study data was collected at the Oregon Pulp and Paper Co. plant at Salem, Oreg., from May 1954 to May 1956.

PROCEDURE

Forty freshly cut, woods-run logs free of significant decay and 40 older logs with some decay were selected for the study. The older logs had lain in the woods for a year or more or had been cut from dead trees. All logs, each about 40 feet long, were trimmed at each end and bucked in half. Then each half was numbered. These numbered logs contained a gross volume of about 57,000 board feet (7,100 cubic feet), about 40 percent of which was sapwood. They averaged 20 inches d.i.b., with the following distribution by diameter groups:

Diameter group (Inches)	Number of logs
7.5 - 10.0	11
10.1 - 15.0	33
15.1 - 20.0	43
20.1 - 25.0	44
25.1 - 30.0	22
30.1 - 33.5	7

As the logs were trimmed and bucked, thin disks were cut from the newly exposed ends, and the percentage of area containing decay was measured. Decay was classified as incipient, intermediate, or advanced; and each stage was measured separately. The disks were kept in dry storage for later reference.

Log diameter and thickness of sapwood were both measured at the small end of each numbered log. Also, the percentage of bark remaining on each log, the extent and occurrence of splits and checks, and the position and pattern of knots were noted.

The logs were then piled on the ground in two adjacent decks, with half of each original log in each deck. All of the logs lay in a north-south direction, with the ends fully exposed. On one of the decks, two heavy-duty sprinklers were installed on short standpipes (fig. 1), and the deck was sprinkled continuously with river water from April until the fall rains in November.

At the end of the first year in storage, half of the fresh logs and half of the old logs in each deck were removed and reexamined

Figure 1.--Sprinkled hemlock log deck near completion of the test. The manner of decking is typical of the way logs are commonly stored for a year or more in the Pacific Northwest, but the pile is considerably smaller than the average found in industry. Note sprinkler atop deck.

to determine if there had been an increase in decay. Each log was trimmed 1 to 2 feet from both ends and thin disks were cut from the newly exposed ends for comparison with the original disks. Again decay area was measured as a percentage of total area and was divided into incipient, intermediate, and advanced stages. After 2 years of storage, this same procedure was used for examining the remaining logs.

In the laboratory, specific gravity was determined for representative sample blocks of wood with incipient, intermediate, and advanced decay and for blocks of sound wood taken from areas adjacent to the decay samples and containing the same annual rings. Specific gravity of the decayed wood before attack was assumed to be the same as that of sound samples.

Surface and interior temperatures of two logs in each deck were measured with thermocouples and a potentiometer. One log was on top of the pile, where it was directly exposed to the sun's rays, and the other was inside the pile at middeck height, where it was shaded. In addition, air temperatures within the decks were recorded on maximum and minimum thermometers.

Temperature readings were taken only during the summer months and not more than once a day. On some days the readings were taken early in the forenoon, when temperatures within the pile would be at lowest values. On other days they were taken late in the afternoon, when temperatures would be maximum.

At the end of the storage period, the moisture content of wood in sprinkled and unsprinkled logs was determined on an ovendry-weight basis. Several decay fungi were identified on the logs or in cultures taken from the logs.

RESULTS AND DISCUSSION

Development of Decay

Water sprinkling of the deck almost completely inhibited the development of decay in green logs. Only a small amount of incipient decay (3 percent of the sapwood) developed during the first year of storage (table 1). After 2 years of storage, 1 percent of the sapwood in the remaining logs had developed advanced decay, but there was no development of incipient or intermediate decay. Heartwood in these logs remained free of decay. Old logs in the sprinkled deck contained some decay in both sapwood and heartwood at the beginning of the test. The increase in total decay in these logs during deck storage amounted to 7 percent in 1 year and 13 percent in 2 years, of which 2 percent in 1 year and 8 percent in 2 years was in the advanced stage. All of this increase occurred in the sapwood.

In the unsprinkled deck, both green and old logs developed additional decay during the storage periods. The green logs developed decay in 22 percent of the sapwood volume in 1 year of storage and 75 percent in 2 years of storage. Nearly all of this increase was in the incipient and intermediate stages. Additional advanced decay in these logs amounted to only 2 percent of the sapwood in 1 year and 8 percent in 2 years. Old logs in this deck developed additional decay of 9 percent of the sapwood in 1 year and 61 percent in 2 years. Not more than half of this amount was in the advanced stage. There was practically no additional decay in the heartwood of the logs.

Table 1.--Development of decay in western hemlock logs during 1 and 2 years of storage in water-sprinkled and unsprinkled decks

(In percent of sapwood volume)

Log type and time in deck (years)[1/]	Average sapwood volume of logs	Decay developed[2/]			
		Incipient	Intermediate	Advanced	Total
UNSPRINKLED DECK					
Green:					
1	49	17	3	2	22
2	39	29	38	8	75
Old:					
1	39	2	5	2	9
2	31	9	19	33	61
WATER-SPRINKLED DECK					
Green:					
1	44	3	0	0	3
2	41	0	0	1	1
Old:					
1	40	2	3	2	7
2	33	3	2	8	13

[1/] At the end of 1 year, 20 green logs and 20 old logs were removed from each deck, cut up, and examined for decay. After 2 years, the remaining logs in each deck were similarly examined.

[2/] Decay during storage developed only in sapwood.

Losses in Specific Gravity and Pulp Yield

Loss in the specific gravity of wood is a good indication of loss in pulp yield.[2/] [3/] The effect of decay on specific gravity varies with the extent, type, and stage of decay; but in all stages, pulp yield is reduced in approximate proportion to the reduction in specific gravity.

Specific gravity of wood from the study logs was tested at the U. S. Forest Products Laboratory (table 2). Based on these specific gravity values, wood containing incipient decay was estimated to suffer a pulp yield loss of 1.7 percent and wood containing intermediate decay, a loss of 4.2 percent. Wood containing advanced decay would normally suffer a loss of 11 percent. However, the additional decay developed during storage was confined to the sapwood. The advanced decay area was so weak that it was entirely removed by the hydraulic barker and the pulp loss was 100 percent for this stage. In this study, pulp yield runs were not made to verify relationships between specific gravity and pulp yield.

In the unsprinkled deck, the volume of decay that developed during 1 year of storage was so small that no loss of pulp yield was indicated. After 2 years of storage, however, fresh logs had developed enough decay to cause a pulp yield loss of 4 percent. Old logs, which contained some decay at the beginning of the test, developed an additional amount to indicate a pulp yield loss of 13 percent during this time. In the sprinkled deck, there was no decay developed during 1 year of storage. After 2 years, the fresh logs remained free of decay, whereas the old logs developed enough decay to cause a pulp loss of 3 percent. These percentages are based on an assumed sapwood volume of 40 percent.

Temperature in Relation to Decay

The rate at which decay develops in wood depends on the prevailing temperature. Fungi that cause wood decay in the Pacific Northwest develop most rapidly at a temperature range between 75° and 85° F.

[2/] McGovern, J. N., Martin, J. S., and Hyttinen, A. Effect of storage of slash pulpwood on sulfate and groundwood pulp quality. Forest Prod. Res. Soc. Proc. 5: 162-169. 1951.

[3/] Lindgren, R. M. Deterioration of southern pine pulpwood during storage. Forest Prod. Res. Soc. Proc. 5: 169-181. 1951.

Table 2.--Effect of decay on specific gravity of wood in decked western hemlock logs

Character of wood	Number of samples	Range in specific gravity	Average specific gravity	Average loss in specific gravity (percent)
Sound	65	0.318-0.510	0.394	0
Incipient decay	48	.324- .465	.387	1.7
Intermediate decay	60	.310- .462	.377	4.2
Advanced decay	87	.271- .442	.351	10.9

Above and below that range, development is slower. Below 55°, decay becomes inactive; above 105°, it makes little growth. Climatic conditions at Salem, Oreg., provide favorable temperatures for development of decay in wood mostly during the warm summer months.

Continuous sprinkling of a deck of logs with water during dry summer weather might be expected to keep the logs relatively cool, due to absorption of heat when water evaporates from the log surfaces. Free-air temperatures within the sprinkled deck, however, were practically the same as in the unsprinkled deck, and these temperatures in both decks were seldom high enough to cause significant progress of decay (table 3). Also, temperatures inside logs within the sprinkled deck differed little from those inside logs within the unsprinkled deck.

In the case of logs placed on top of the deck, where they were exposed directly to the sun, the log in the unsprinkled deck sometimes showed afternoon temperatures as high as 122° F. under the bark. Temperatures within the log reached levels above 75° F., favoring rapid decay. In the sprinkled deck, the temperature of the top log was only slightly above that of the shaded logs within the deck.

Table 3.--Temperature of western hemlock logs in unsprinkled and water-sprinkled decks[1/]

Location and station		Date, hour, wind,[2/] and cloud cover			
		7-7-55; 4:20 p.m.; Gentle; Showers.	7-12-55; 3:00 p.m.; Gentle; None.	7-15-55; 9:00 a.m.; Gentle; Overcast.	7-19-55; 3:00 p.m.; Gentle; None.
		Degrees (F.)			
UNSPRINKLED DECK					
Top log:					
at surface	1	91	129	82	126
below bark	2	87	122	81	118
1" deep	3	94	69	81	113
3" deep	4	93	94	82	94
12" deep	5	79	67	87	69
Log in pile:					
at surface	6	62	77	59	67
below bark	7	60	79	61	64
1" deep	8	60	77	58	63
3" deep	9	55	67	--	64
12" deep	10	52	60	60	60
Air in pile	21	63	--	63	73
(24-hr. max.-min.)	--	--	74-56	85-59	75-51
WATER-SPRINKLED DECK					
Top log:					
at surface	16	73	91	63	78
below bark	17	72	88	66	84
1" deep	18	71	83	66	76
3" deep	19	67	75	65	67
12" deep	20	59	69	70	64
Log in pile:					
at surface	11	57	82	58	70
below bark	12	70	74	54	68
1" deep	13	70	78	56	70
3" deep	14	69	72	61	66
12" deep	15	61	65	61	65
Air in pile	22	60	--	--	71
(24-hr. max.-min.)	--	--	--	--	72-50

[1/] Representative of daily readings during the study.

[2/] Beaufort's scale, estimated.

It was tentatively concluded therefore that the reduction in development of decay in the sprinkled deck was not due to cooling.

Moisture Content in Relation to Decay

A favorable moisture content of wood is necessary for the start and development of decay. Wood containing less than 20 percent moisture (dry-weight basis) does not decay, and for decay to progress fairly rapidly, a moisture content of 30 percent or more is required. However, oxygen is also necessary for the growth of wood-rotting fungi, and decay will not develop when complete saturation with water eliminates air from the wood.

The average moisture content of wood samples from the sprinkled logs was 109.3 percent, dry-weight basis. The variation in moisture content was 82.1 to 149.0 percent. For the unsprinkled logs, the average moisture content was 64.1 percent, and it varied from 41.3 percent to 92.4 percent.

For the climatic conditions under which these tests were made, it appeared that the logs from the sprinkled deck developed much less additional decay than those in the unsprinkled deck because of the higher moisture content of the wood.

Fungi Causing Decay

The most common decays found in the decked logs were identified. Only the sporophores of Lenzites saepiaria (Wulf.) Fr. were found fruiting, mostly on the top logs in the unsprinkled deck. Other wood-rot fungi isolated in culture were Fomes pinicola (Fries) Cooke, F. annosus (Fries) Cooke, F. nigrolimitatus (Romell) Egel., Stereum sanguinolentum Fries, and Polyporus adustus Willd. ex Fr.

F. pinicola was most commonly found in the older logs. F. annosus and S. sanguinolentum occurred frequently in both green and old logs. In green logs, all three fungi appeared to be frequently associated with old wounds. The latter two cause less loss in pulp yield than fungi in the brown cubical group typified by F. pinicola and L. saepiaria.

Trichoderma and Penicillium molds frequently contaminated the cultures, especially those made from the rot in old logs.

CONCLUSIONS

Under climatic conditions similar to those in the study:

1. Both green and old western hemlock logs can be stored in unsprinkled decks for 1 year without appreciable additional decay and loss in pulp yield. Green logs can be decked for as long as 2 years without serious additional loss, but old logs containing decay when decked suffer considerable loss.

2. Constant sprinkling with water during the warmer months of the year, so as to keep ends and faces of logs wet at all times, effectively inhibits the development of additional decay in old logs and prevents additional pulp yield loss in decked western hemlock.