TESTS OF DECAY RESISTANCE OF FOUR WESTERN POLE SPECIES

October 1954

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(Report) No. 2006

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison 5, Wisconsin
In Cooperation with the University of Wisconsin

TESTS OF DECAY RESISTANCE OF FOUR WESTERN POLE SPECIES

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Summary

To compare the natural decay resistance of heartwood of western redcedar, western larch, Douglas-fir, and lodgepole pine, accelerated decay tests were made on samples from pole-size trees of these species growing in the Inland Empire. Emphasizing the outer heartwood because of its strategic position, two general classes of decay resistance were indicated: resistant, represented by the redcedar from the lower and middle thirds of the pole, and moderately resistant, represented by the redcedar from the upper part of the pole and by the other woods from all parts of the pole. Among the species other than western redcedar, larch tended to be most resistant and lodgepole pine least resistant, but these differences usually were not large and were not consistent for all tests. Differences in sapwood thickness and checking tendencies also would be important factors in determining how these species would perform as poles.

There were prominent radial as well as vertical differences in the resistance of western redcedar, the outer heartwood being most resistant and the inner heartwood least resistant. Differences of the same type, but lesser magnitude, occurred in western larch. There was no apparent relation between decay resistance and the growing site of the tree, or the age or size of the tree in any of the woods. Decay resistance was plainly correlated with the specific gravity of the wood in western larch but not with that of the other species.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Internal sapwood present in several western redcedar and western larch trees was no more resistant to decay than normal sapwood. The interior decay resistance of a pole containing internal sapwood would, therefore, be less than that of a pole without it.

Introduction

Western redcedar, western larch, Douglas-fir, and lodgepole pine have physical characteristics that make them suitable for poles. But the heartwood of round poles of these species generally is not penetrated by preservatives in commercial treatment. Consequently, the heartwood has no special protection from decay at points where the covering shell of treated sapwood becomes ruptured, as by seasoning checks or by climbers' spurs. This has raised a question about the natural decay resistance of western larch, Douglas-fir, and lodgepole pine heartwood in comparison with that of western redcedar, which has long been recognized as adequate for poles. Field and laboratory tests of decay resistance were therefore made to answer the question for pole-size trees in the Inland Empire.[2]

Procedure

Sampling

Material for testing was collected from freshly felled trees in Idaho and Montana, and in Washington just west of the Idaho line. A summary description of the sampled trees of each species is given in table 1. From each of these trees an 18-inch bolt was taken from what would correspond to the groundline of the pole. This was usually about 4 to 6 feet above the stump cut, depending on the pole size. In addition, bolts were taken from six western redcedar and seven western larch trees at the top, and midway between the top and base of the trees.

In the laboratory, 1- by 1- by 18-inch sticks were sawed from the heartwood portion of the bolts. As permitted by bolt diameter, cedar and larch stakes were taken from three radial zones: outer heartwood, middle heartwood, and inner heartwood, falling respectively within the outer, middle, and inner one-third of the heartwood radius. The Douglas-fir and pine bolts were sampled in the outer heartwood only,

[2]Includes Montana west of the Continental Divide, Idaho north of the Salmon River, and eastern Washington.

since on the basis of background information, important radial differences in decay resistance in these woods seemed unlikely. In all cases the same zone was sampled twice, on opposite sides of the bolt.

Some of the sticks from each zone were cut into 7-inch lengths, and these short stakes made up the sample material for the field tests. The remainder of the sticks were cut into blocks 3/8 inch long for the laboratory decay test.

Testing for Decay Resistance

Three field tests were made. One test plot was near Gulfport, Miss., one near Missoula, Mont., and one at Madison, Wis. Usually four stakes from each sampled position in a tree were placed on each plot. The stakes were partially randomized for position on a plot and were set to a depth of 6 inches. They were left in test for 4 years.

The laboratory test was made by exposing the blocks to attack by pure cultures of six brown-rot fungi: *Fomes roseus* (Madison 701), *Lentinus lepideus* (Mad. 534), *Lenzites trabea* (Mad. 617), *Poria incrassata* (Mad. 563), *P. monticola* (Mad. 698), and *P. xantha* (Beltsville 94155). All of these fungi are prominent causes of decay in coniferous wood, and all but *P. xantha* have been extensively used in other tests.

The soil-block method of testing was used. Six-ounce French square bottles were half filled with moist, fertile top soil, and a 1- by 1- by 1/4-inch feeder block of pine sapwood was laid on top of the soil. The bottles thus prepared were sterilized by autoclaving, cooled, and inoculated with one of the test fungi. Three weeks later, the test blocks were put in bottles, separately by species, and partially sterilized with steam at 212° F. for 20 minutes, and when cool were laid, one to a bottle, on top of the then overgrown feeder blocks. Lastly, the bottles were held for 3 months in a room maintained at 80° F. and 70 percent relative humidity.

Amounts of decay in both field stakes and laboratory test blocks were measured by the percentage loss in the dry weight of the wood. Before and after the test, the samples were dried to equilibrium weight in a room maintained at 80° F. and 30 percent relative humidity. Losses were measured from these equilibrium weights.

Results

Differences Among Tests

Weight losses produced by decay in the different woods and under the different test conditions are summarized in table 2.[3] Although differences occurred between tests in amount of decay, the relative order of decay resistance exhibited by the different woods tended to be similar. Save in a small part of the test plot, decay of all woods at Missoula was slight, and significant differences among the woods were not brought out. Differences between the Madison and Gulfport tests in overall amounts of decay occurring in the larch, Douglas-fir, and pine stakes were small. In the case of the redcedar, however, much more decay occurred on the Gulfport than on the Madison plot.

The slight amount of decay at Missoula reflects the comparatively dry climate of the area. Deeper stakes, reaching moister soil, possibly would have undergone more decay. The Gulfport plot was expected to produce maximum amounts of decay because of its semi-tropical environment. Its failure to do this except in the redcedar is attributed to low fertility and restricted microorganism population of the soil on the plot, although the relation of decay rate to soil character is uncertain. The marked vulnerability of the redcedar at Gulfport, where decay otherwise was comparatively moderate, suggests a weakness of this species that is not shared by the others. Apparently a considerable portion of the extractives responsible for the redcedar decay resistance was leached out of the wood by the prevalently wet soil at Gulfport. In support of this explanation, decay of the redcedar stakes at Gulfport tended to be confined to the outer zones, whereas in the other tests the stakes were more uniformly affected when attacked.

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[3] Average losses shown in table 2 for middle and inner heartwood deviate slightly in some cases from the observed values. All cedar and larch trees were tested at the outer heartwood, but only part of them at the middle and inner heartwood. Average weight losses for the middle and inner heartwood, therefore, were adjusted so as to maintain the same differences between them and the outer heartwood averages as were actually found in trees in which both were tested. Thus the listed averages are strictly as found for the outer heartwood and approximately what might be expected for the other positions had those positions been tested in all trees. No significant changes were effected by similar adjustments for comparing weight losses in wood from different elevations in the trunk; consequently, none were made.

Relative Heartwood Decay Resistance of the Different Woods

The foregoing indicates that environmental conditions also may influence the relative as well as the overall rates of decay in different woods. Consequently, the decay resistance of the different woods considered here must be appraised partially in the light of individual test conditions. To facilitate the comparisons, figure 1 was prepared. This is a graphic portrayal of the averages shown in table 2, omitting the Missoula results. For better practical perspective, results for the three different radial positions in the trunk are illustrated by bars of different width. The widths are proportional to the different trunk volumes represented by the outer, middle, and inner one-third of the heartwood (ratios of volumes are, respectively, 5:3:1).

Within individual redcedar trees the decay resistance varied greatly according to a fairly well-defined pattern. Generally the outer heartwood was more resistant than the inner heartwood, and wood of the lower trunk was more resistant than that of the upper trunk. This pattern of resistance has been found in a number of other woods. Where pronounced, it should be considered in characterizing the decay resistance of a species. It may be seen from figure 1 that there was a similar variation in resistance in the larch trees, although not of sufficient magnitude to be of practical importance. Slight radial trends but no vertical trends of decay resistance were found in an earlier study of second-growth Douglas-fir.[4] Neither radial nor vertical trends were apparent in supplementary tests of the lodgepole pine. It appears from these observations and earlier ones on other woods that within-tree variation in heartwood decay resistance is generally greatest in the most resistant species.

Keeping in mind this within-tree variation, the decay resistance of the four woods may now be compared. Western larch tended for the most part to be a little more resistant than Douglas-fir and Douglas-fir a little more resistant than lodgepole pine. Western redcedar was both more and less resistant than the other woods, depending on the test and on the portion of the trunk sampled.

In the laboratory test, which provided little opportunity for leaching, western redcedar exhibited markedly superior decay resistance throughout most of the lower trunk and in the outer heartwood of the central trunk. Through the remainder of the trunk (upper trunk and middle and inner heartwood of the central trunk) it was just slightly more resistant than the larch. In the field test at Madison, where leaching was conditioned by annual precipitation

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[4] Scheffer, Theodore C., and Englerth, George H. Decay resistance of second-growth Douglas-fir. Jour. of For. 50(6):439-442. 1952.

averaging about 30 inches and frozen top soil during winter months, the outer heartwood of the lower and central redcedar trunk was moderately more resistant than the larch and the remainder of the trunk was only slightly if at all more resistant. In the Gulfport test, where the annual rainfall averaged more than 60 inches, the resistance of western redcedar from all positions in the trunk was inferior to that of western larch, and mostly by a large margin.

Decay Resistance in Relation to Tree, Wood Character

In none of the woods was there an evident relation between decay resistance and the growing site of the tree, or the age or size of the tree. Absence of any correlation with age or size was surprising in view of the wide ranges dealt with and the fact that age and size are known to be prominent factors in certain other woods[5,6] and weak factors in Douglas-fir.[4] Presumably some correlations would have been disclosed had a larger number of trees been tested, but it is apparent that they would be overshadowed by differences in resistance that are inherited or more closely tied to other factors.

The resistance of the western redcedar and western larch was weakly related to the rate at which the wood was grown, being slightly greater as the number of rings per inch was greater. It was related in a well-defined manner to specific gravity in western larch, and less plainly in the Douglas-fir and lodgepole pine -- which were represented by fewer trees. There was no evidence of a resistancé-gravity relation in the redcedar. It should be pointed out here that specific gravity of itself seems not to be much of a factor of decay resistance but in some woods there may be indirect correlation because of a relation between gravity and the chemical constituency primarily responsible for the decay resistance of the wood.

Of the 15 western redcedar trees and 18 western larch trees, 6 of each species contained so-called "internal sapwood," which showed in cross section as concentric bands of light wood interspersed with the darker heartwood (figure 2). This internal sapwood had no more resistance to decay than normal sapwood, hence it would

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[5] Scheffer, Theodore C., and Hopp, Henry. Decay resistance of black locust heartwood. U. S. Dept. Agr. Tech. Bul. 984. 37 pp. 1949.

[6] Scheffer, Theodore C., Englerth, Geo. H., and Duncan, Catherine G. Decay resistance of seven native oaks. Jour. Agr. Res. 78(5 and 6):129-152. 1949.

detract from the overall decay resistance of a pole, especially if one of the bands were close enough to the heartwood boundary to be reached by seasoning checks. Heartwood adjacent to bands of internal sapwood was normal in its resistance to decay.

Discussion and Conclusions

The levels of decay resistance indicated by the laboratory test for western redcedar and Douglas-fir are in line with findings for a larger number of samples of the same woods from other areas. Comparable supplementary test data for western larch and lodgepole pine have not been gathered, but it may be noted that the relative resistance exhibited by these two woods in the present tests is in agreement with their reputations for decay resistance. Except for the western redcedar, differences in resistance displayed among the four woods in the laboratory test were similar to those in the field tests. As the laboratory evidence in all respects conforms to the limited information from other sources about the woods, it probably is a fairly representative portrayal of differences to be found among the species in most kinds of service.

A very general appraisal of the decay resistance of the four woods is perhaps sufficient for the practical needs of the pole producer and user. For such an appraisal the resistance of the outer heartwood should be emphasized, since the outer heartwood, as here sampled, not only constitutes more than half the heartwood volume but serves as the "front-line" barrier to heartwood infection in a pole. From this point of view, therefore, and judging western redcedar mainly from the evidence of the laboratory test, the resistance of the heartwood of the different woods to decay in poles appears to be most commonly as follows:

Resistant: Western redcedar in the lower and middle thirds of the pole.

Moderately resistant: Western redcedar in the upper third of the pole, and western larch, Douglas-fir, and lodgepole pine at all heights in the pole. Lodgepole pine appeared to be the least resistant and western larch the most resistant of the three last-named woods, but differences were not large, especially for the range of moderate decay resistance.

In the foregoing comparisons, no point is made of the moderate to low decay resistance exhibited by western redcedar in some of the field tests, because it was felt that those results were not representative of redcedar performance in pole sizes. The field results undoubtedly depict the situation correctly for western redcedar heartwood stakes of small size; therefore, the indicated loss of redcedar decay resistance through leaching should be kept in mind when using this species in damp ground. Nevertheless, in view of the reputation of the wood for decay resistance, redcedar probably does not suffer marked loss of decay resistance when used in post and larger sizes. Perhaps the greater reservoir of natural preservatives in large material keeps the outer wood resistant to fungus attack for longer periods than are typical of small material like test stakes. But whatever advantage large size may be for maintaining decay resistance in western redcedar, preservative treatment of the sapwood of round items like poles should have considerable influence. Leaching of the heartwood hardly can be much of a factor through the overlying sound sapwood, especially if the sapwood has received an oil-type preservative. Experimental evidence to this effect was found by one of the writers in redcedar poles that had been in line 20 to 30 years.

The likelihood of heartwood decay in a pole is determined not only by the decay resistance of the heartwood but also by the extent to which the heartwood may be exposed to infection through checking or other rupturing of the protecting cover of treated sapwood. It is not a function of this paper to speculate on the relative significance of the latter factor for the four pole species being considered. However, it seems appropriate to point out the sapwood thickness of the respective woods, since this bears strongly on the situation. From data furnished by Hearn,[7] common depths of sapwood are approximately as follows: western redcedar - 0.73 inch, western larch - 0.70 inch, Douglas-fir (mainly Coast type) - 1.29 inches, and lodgepole pine - 1.30 inches. Limited data gathered at the Forest Products Laboratory on pole-size material indicate that the sapwood thickness of Rocky Mountain type Douglas-fir tends to be substantially less than that of Coast type.

[7] Hearn, A. H. Relationship between sapwood thickness and depth of preservative penetration in Pacific Coast Douglas-fir poles. Proc. Am. Wood. Pres. Assn. 47:135-151, table 17. 1951.

Table 1.--Description of sampled trees

Factor	Measure	Wood			
		Western redcedar	Western larch	Douglas-fir	Lodgepole pine
Number of trees sampled	....	15	18	6	10
Pole class[1]	Range	2-6	1-7	1-6	4-7
	Most frequent	4	4	6	6
Pole length (feet)	Range	18-60	15-60	40-50	30-55
	Average	47	43	45	42
D.B.H. (inches)	Range	6.7-18.2	7.0-19.0	10.0-18.2	9.4-14.3
	Average	12.5	13.1	12.7	11.4
Age at stump height (years)	Range	85-250	60-315	60-208	58-220
	Average	134	133	127	121
Crown class	Range	Intermediate-suppressed	Intermediate-dominant	Intermediate-dominant	Intermediate-dominant
	Most frequent	Suppressed	Dominant	Codominant	Codominant
Growing site	Range	Good-optimum	Medium-optimum	Poor-good	Good-optimum
	Most frequent	Optimum	Optimum	(Equal)	(Equal)
Specific gravity of outer heartwood[2]	Range	0.32-0.43	0.60-0.89	0.43-0.59	0.42-0.57
	Average	0.37	0.69	0.49	0.48
Rings per inch in outer heartwood	Range	12-38	12-71	8-40	8-55
	Average	23	34	23	27

[1] According to American Standard Specifications and Dimensions for Wood Poles, A.S.A. No. 05.1-1948.

[2] Based on weight and volume when oven dry.

Table 2.--Results of decay tests of heartwood from different parts of pole-size trees of western redcedar, Western larch, Douglas-fir, and lodgepole pine

Wood species	Number of trees for Test A	B	C	D	Heartwood zone	Test A, Gulfport plot: Range	Test A, Gulfport plot: Average[3]	Test B, Missoula plot: Range	Test B, Missoula plot: Average[3]	Test C, Madison plot: Range	Test C, Madison plot: Average[3]	Test D, In laboratory[2]: Range	Test D, In laboratory[2]: Average[3]
						Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
LOWER TRUNK													
Cedar	14	15	15	15	Outer	7-52	19	2-8	3	4-26	13	4-26	11
Cedar	4	4	6	4	Middle	12-25	22	2-4	3	4-30	19	8-20	15
Cedar	5	6	6	6	Inner	16-34	26	2-11	5	5-20	16	11-26	19
Larch	17	18	18	18	Outer	12-19	14	2-13	6	8-36	18	21-32	27
Larch	3	3	3	4	Middle	14-18	17	4-14	7	7-28	23	26-32	28
Larch	6	6	6	6	Inner	13-20	16	3-7	5	11-26	23	24-35	29
Douglas-fir	6	6	6	6	Outer	12-22	18	2-8	4	14-17	15	30-37	33
Pine	9	10	10	10	Outer	12-29	20	1-9	3	12-37	26	34-43	38
CENTRAL TRUNK													
Cedar	6	6	6	6	Outer	15-34	25	3-10	6	10-19	14	11-26	17
Cedar	2	2	3	3	Middle	31-34	27	4-6	5	7-22	14	21-32	27
Cedar	3	6	6	6	Inner	23-26	19	2-15	6	8-29	19	17-33	27
Larch	6	6	6	6	Outer	11-17	14	3-9	6	12-27	19	26-32	29
Larch	3	3	3	4	Middle	16-18	16	3-14	5	18-21	19	31-34	32
Larch	4	6	6	6	Inner	14-20	16	1-20	6	11-26	17	26-39	32
UPPER TRUNK													
Cedar	5	6	6	6	Outer	26-35	30	3-16	5	4-28	18	17-36	26
Larch	7	7	7	7	Outer	12-20	16	2-6	4	7-29	18	27-32	30
Larch	2	2	2	2	Middle	19-20	22	4-12	8	16-20	17	27-33	31
Larch	5	5	5	6	Inner	17-20	19	4-13	8	13-27	21	30-35	32

Weight loss in field tests (stake samples) and in the laboratory test (block samples)[1]

[1]Each field-test average is based on trials of usually 4 stakes per tree, and each laboratory-test average on 24 blocks per tree (4 for each test fungus).
[2]Listed results are averages for 6 test fungi.
[3]Average losses shown for middle and inner heartwood deviate slightly in some cases from the observed values. (See footnote 4, text).

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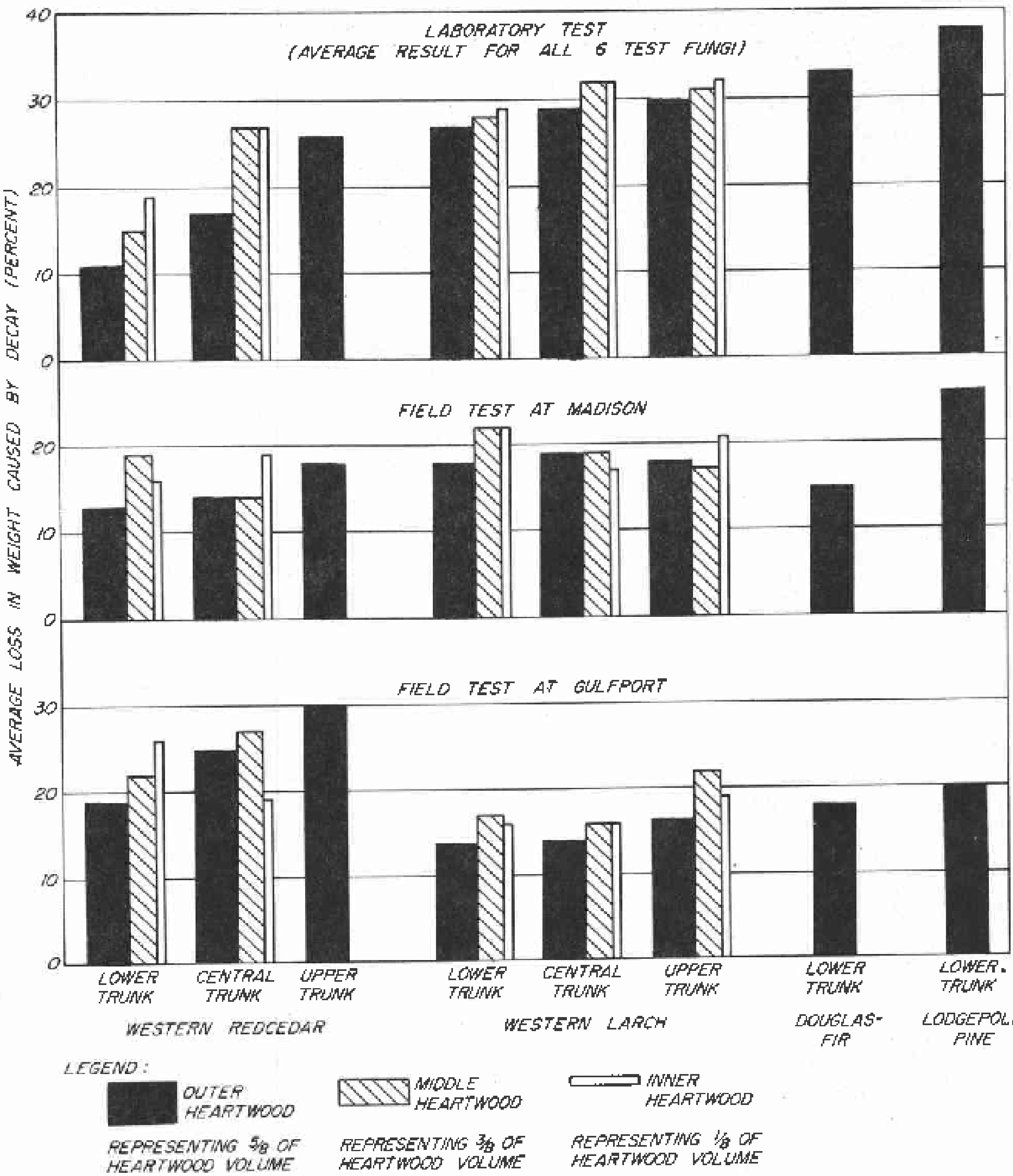

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Figure 1.--Graphic comparison of decay resistance in the tested woods (based on table 2).

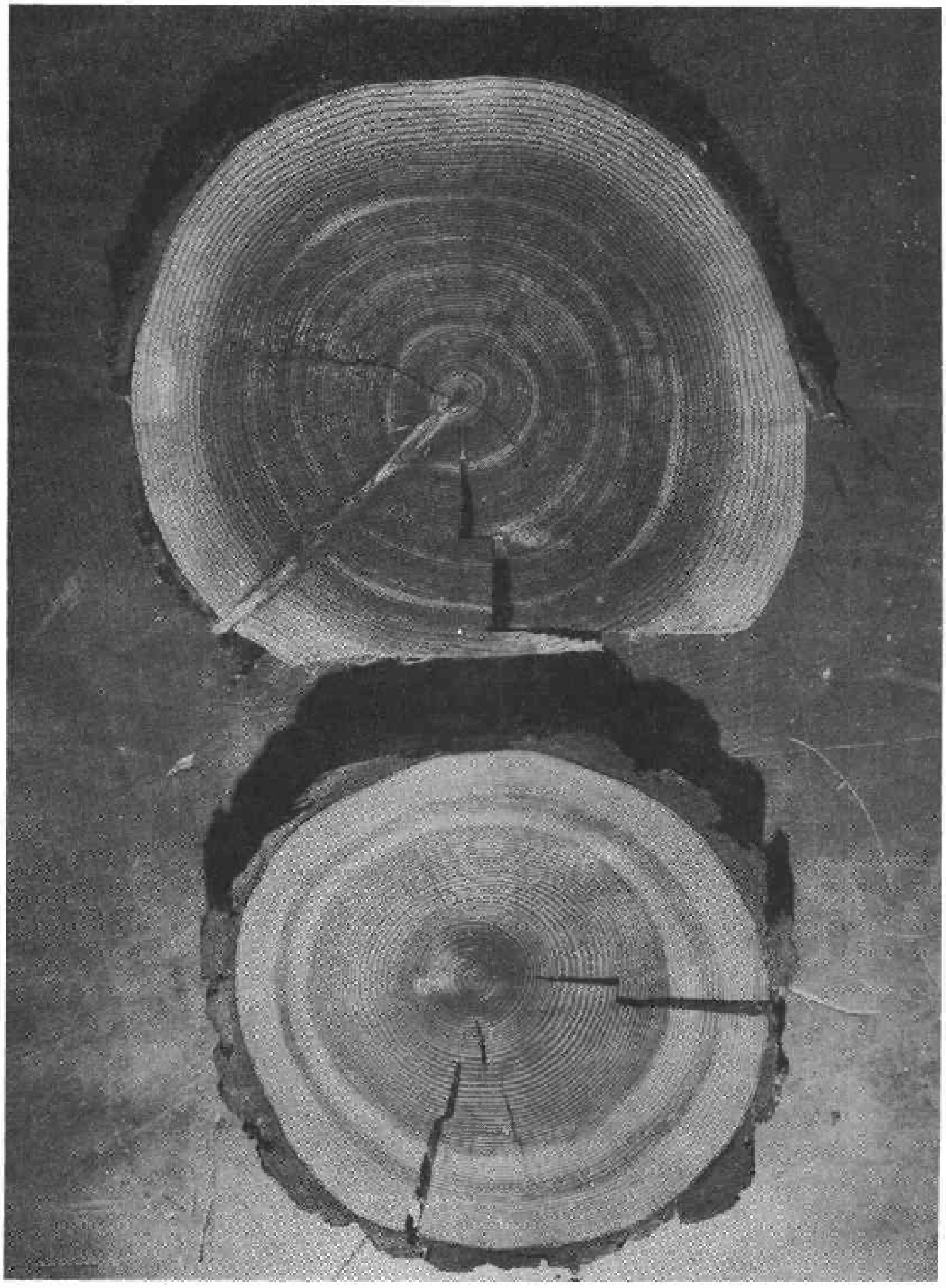

Figure 2.--Basal sections from western redcedar (upper) and western larch trees showing bands of so-called internal sapwood.

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