Decay Resistance and Susceptibility of Sapwood of Fifteen Tree Species

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ABSTRACT

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Twelve softwoods and three hardwoods were tested for resistance or susceptibility to decay above-ground by (i) soft-rot fungi: *Papulospora* sp., *Monodictys* sp., *Graphium* sp., *Dactylomyces crustaceous*, *Penicillium* sp., *Thielavia terrestris*, and *Allescheria* sp.; (ii) white-rot fungi: *Coriolus versicolor*, *Phanerochaete chrysosporium*, *Lentinus tigrinus*, *Ganoderma applanatum*, and an unknown basidiomycete; and (iii) brown-rot fungi: *Gloeophyllum saepiarium*, *G. trabeum*, *Poria placenta*, and *Lentinus lepideus*. All woods except the hardwoods and two of the softwoods underwent little weight loss (0-10%) when tested against soft-rot fungi by the serial-block method.

White- and brown-rot fungi were used in an agar-block test designed to promote a relatively slow rate of decay. With white-rot fungi, all hardwoods were very susceptible to decay (45% or more weight loss); all but two of the softwoods sustained 11-24% weight loss. Five woods were very susceptible to decay (45% or more weight loss) by brown-rot fungi, nine were less susceptible (weight loss of 25-44%), while *Eucalyptus* was very resistant (0-1% weight loss).

A measure of the relative importance of each of the test fungi, based on overall decay capabilities, is provided. Additionally, host preferences and deviations from preference trends are discussed for each of the fungal groups.

Additional key words: Pseudotsuga menziesii, Picea engelmannii, P. glauca var. *albertiana, P. sitchensis, Pinus ponderosa, P. monticola, P. contorta* var. *latifolia, P. resinosa, Pinus* sp., *Tsuga heterophylla, Thuja plicata, Sequoia sempervirens, Populus balsamifera, Alnus rubra,* serial-block test, purified agar-block method, mesophile, thermophile.

Natural decay resistance of heartwood of trees is due mainly to the deposition of fungitoxic substances in cell walls during their transformation in the tree from sapwood to heartwood. Sapwood, on the other hand, lacks these toxic extractives and is generally susceptible to decay.

Much work has been done to determine comparative decay resistance of the heartwood of different species (24); sapwood, owing to its general susceptibility to fungal attack, has been accorded little such attention. Decay testing generally is conducted under conditions that would cause most sapwoods to decay too rapidly for comparisons of decay resistance or susceptibility to be made. However, information about decay resistance of sapwood of different tree species now is needed to answer questions regarding (i) the longevity of such wood in above-ground situations and (ii) host-fungal preferences for certain wood groups; hence the present investigation. To determine longevity under above-ground conditions, less severe decay tests are needed.

As early as 1916, Humphrey (11) conducted durability tests on sapwood and heartwood of 28 coniferous species. *Lentinus lepideus* Fr. was the test fungus and periods of incubation were 4, 6, and 12 months. For the sapwood of 19 species the average weight loss after 4 months of incubation was 24.4%, with little variation in susceptibility among species. In the remaining nine species, weight losses were much lower but this was attributed to the test blocks becoming too wet during the testing. Later, Hubert (10) tested the decay resistance of sapwood and heartwood of eight commercial western woods and redgum, using *Gloeophyllum trabeum* (Pers.) Murr. and an incubation period of 8 months. His results differed from those of Humphrey (11) in that sapwood weight losses of test specimens ranged from 0% for western red cedar to 20% for sugar pine. Hubert (10) did not consider the results of this work conclusive enough to use as a measure of the specific decay resistance of these woods.

Soshiroda (20) tested three Japanese conifers against *Poria vaporaria* Pers., and found that weight losses ranged from 0.9% to 19.4%. Scheffer and Duncan (19), working with tropical hardwoods and using brown-rot test fungi, also found a considerable range in sapwood decay susceptibility between wood species.

Wide variations in weight losses due to soft-rot occurred when sapwood blocks of aspen, birch, pine, and spruce were subjected to attack by 20 different fungi. Generally decay was highest in the aspen and lowest in spruce (2). Similarly, resistance of the sapwood of 61 Japanese hardwoods to decay by the soft-rot fungus, *Chaetomium globosum* Kunze, varied significantly (22).

However, little variation in resistance between 18 softwood species was found.

Differences in the decay susceptibility of sapwood of different species (2, 19, 22) are sufficiently large to warrant further investigation with American woods.

The objective of the present study was to determine the comparative resistance of the sapwood portion of some American wood species to decay by white-rot, brown-rot, and soft-rot fungi. This information would aid in estimating service life of different species when used under conditions only moderately favorable to decay (i.e., no contact with soil). Information relative to consistency of decay resistance of the sapwood of individual tree species or of a group of species and preferences of fungi for certain wood species also was sought.

MATERIALS AND METHODS

Wood species.—The 15 woods involved included: Douglas-fir [*Pseudotsuga menziesii* (Mirb. Franco)]; Engelmann spruce (*Picea engelmannii* Parry); western white spruce [*Picea glauca* var. *albertiana* (S. Brown) Sarg.]; Sitka spruce [*Picea sitchensis* (Bong.) Carr.]; ponderosa pine (*Pinus ponderosa* Laws.); western white pine (*Pinus monticola* Dougl.); lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.); western hemlock [*Tsuga heterophylla* (Raf.) Sarg.]; western red cedar (*Thuja plicata* Donn.); redwood [*Sequoia sempervirens* (D. Don) Endl.]; balsam poplar (*Populus balsamifera* L.); *Eucalyptus* sp.; red alder (*Alnus rubra* Bong.); southern pine (*Pinus* sp.); and red pine (*Pinus resinosa* Ait.).

For each species, four sapwood slabs were obtained, each of which was presumed to have come from a different tree.

Fungal species.—White-rot fungi included in the present testing were: *Coriolus versicolor* L. ex Fries (Mad-697); *Lentinus tigrinus* (Bull.) Fries (ME-6); *Ganoderma applanatum* (Pers. ex Wallr.) Pat. (Mad-708); *Phanerochaete chrysosporium* Burds. [ME-461, previously identified as *Peniophora* "G" (3)]; and an unknown basidiomycete (ME-485).

Brown-rot fungi included: *Gloeophyllum saepiarium* (Wulf.) Karst. (Mad-604); *G. trabeum* (Pers.) Murr. (Mad-617); *Lentinus lepideus* Fr. (Mad-534), and *Poria placenta* (Mad-698). For many years the isolate Mad-698, known as *Poria monticola* Murr., has been distributed worldwide and utilized as a standard decay test fungus. Because of its importance in this work, our adoption of the new name *Poria placenta* (Fr.) Cke. for this isolate deserves explanation.

The isolate originally was identified as *Poria microspora* Overh. on the basis of comparison with the culture derived from the type specimen. Later, Overholts placed *P. microspora* into synonymy with *P. monticola*. Recently, Domański (4) determined the synonomy of American isolates of *P. microspora* (as *P. monticola*) with those of the European fungus, *P. placenta*, by successful haploid pairing. The Friesian name "placenta" is the earliest legitimate name according to Article 11 of the International Code (21).

Mesophilic and thermophilic soft-rot fungi, all isolated from wood chip storage piles (7, 13) also were used as test organisms. The mesophiles were: *Papulospora* sp. (ME-PC-19, from southern pine chips); *Monodictys* sp. (ME-GC-18, from gum chips), and *Graphium* sp. (ME-BC-11, from beech chips). Thermophilic fungi included: *Dactylomyces crustaceous* Alpinis and Chesters (ME-T-BIC-6, from birch chips); *Allescheria* sp. (ME-T-BC-9, from beech chips); *Penicillium* sp. (ME-T-BC-10, from beech chips), and *Thielavia terrestris* (Alpinis) Malloch and Cain (H-63-1, obtained through the courtesy of the Kungl. Lantbrukshögskolans Mikrobioliska Institutionen, Sweden).

Decay tests with soft-rot fungi.—The serial-block test (8), conceived for determining decay capabilities of soft-rot fungi that inhabit wood chips, was used. Sixty-four blocks, each 2.54 × 1.27 × 0.63 cm with the 0.63-cm dimension in the grain direction, were cut from each of the four boards of each species. The blocks were numbered, conditioned (stored at 27 C and 70% RH), weighed, and steam-sterilized for 30 minutes at 100 C. Eight replicate blocks from each board were strung together and then subjected to the attack of one of the soft-rot test fungi. After 12 weeks of incubation at 27 C for mesophilic fungi, and at 45 C for thermophilic fungi, the blocks were removed from test, reconditioned, weighed, and their weight losses calculated.

Decay tests with basidiomycetes.—The standard ASTM soil-block method of determining decay resistance of wood (1) involves contact of the test wood with soil, which provides a source of nutrients for the fungi, thus enhancing decay. Because this method is considered too severe for application with sapwood, a low decay-promoting method was employed that utilized purified agar in place of soil (9).

Test blocks, 2.54 × 2.54 × 0.94 cm with the 0.94-cm dimension in the grain direction, were cut from the boards of each species. No attempts were made to separate blocks from different boards of the same species, as had been done for soft-rot testing. The blocks were numbered, conditioned, weighed, and steam-sterilized at 100 C for 30 minutes. They were aseptically inserted into test bottles and placed upon preinoculated 2.54 cm squares of filter paper laid over glass triangles. The triangles rested on 1.5% Difco purified agar which provided moisture for fungal growth.

Six blocks of each wood species were exposed to each of the white- and brown-rot fungi. The blocks were incubated at 27 C for 12 weeks. They then were removed, conditioned, weighed, and their weight losses calculated.

Statistical analysis.—The fungal weight losses were subjected to analysis of variance with multiple comparisons. Owing to homogeneity of variance problems it was necessary to separate the three fungal groups (soft-rot, white-rot, and brown-rot fungi) and to run the tests for each group independently of the others. Thus, it was not possible to compare fungal groups. All tests were made at $P = 0.05$.

RESULTS

Soft-rot tests.—In the serial-block method, the maximum weight loss in each replicate series of test blocks is the measure of resistance to attack by soft-rot fungi. Four replicate series of blocks per fungus and wood were used here. Average maxima are reported (Table 1).

For each fungus the weight losses caused in the different wood species were compared statistically (Fig.

Soft-rot fungi	Wood species	White-rot fungi	Wood species	Brown-rot fungi	Wood species
P	WR DF WH RP R SP ES SS WS LP RA E PP WP BP	CV	PP WH SS SP R DF WS WP ES WR RP LP BP RA E	GS	E RA R WH SP DF PP SS WR WP WS BP ES LP PP
M	DF WR WH WS LP PP SS WP R RP SP ES BP E RA	PC	WS SS PP WH WR R RP ES SP WP DF RA BP LP E	PP	E WH RA SS SP WP R WS ES DF RP PP LP WR BP
G	WR DF RP SS WH PP LP WP WS SP R ES E BP RA	LT	WH DF WS R SS WR SP ES PP LP WP E RP BP RA	GT	E R WH SS DF WS WP PP SP LP RA RP BP
DC	DF PP WR RA ES WS RP WH LP R SS SP BP WP E	GA	WH PP DF SS WS SP LP RP R WP BP RA E	LL	E RA R WS WH SS SP PP DF BP RP WP LP
A	WR WH DF RP ES R SP PP WS SS WP LP E RA BP	ME	E DF WS WH PP R RA BP SS SP WR ES WP LP RP		
PE	DF WR PP WH SS RP R SP ES WS LP WP E RA BP				
TT	WR DF PP WH SS WS RP SP R LP WP ES E BP RA				

Pairwise comparisons of the various means were made by ordering the means from lowest to highest and then drawing a line connecting those which show no significant difference. Successive lines show additional nonsignificant groupings. Within each fungal group all comparisons were made with a 95% simultaneous confidence level.

Fungi:

P = *Papulospora* sp.
M = *Monodictys* sp.
G = *Graphium* sp.
DC = *D. crustaceous*
A = *Allescheria* sp.
PE = *Penicillium* sp.
TT = *T. terrestris*
CV = *C. versicolor*
PC = *P. chrysosporium*
LT = *L. tigrinus*
GA = *G. applanatum*
ME = Unknown (ME-485)
GS = *G. saepiarium*
PP = *P. placenta*
GT = *G. trabeum*
LL = *L. lepideus*

Wood:

WR = western redcedar
DF = Douglas-fir
WH = western hemlock
RP = red pine
R = redwood
SP = southern pine
ES = Engelmann spruce
SS = Sitka spruce
WS = white spruce
LP = lodgepole pine
RA = red alder
E = Eucalyptus sp.
PP = ponderosa pine
WP = western white pine
BP = balsam poplar

Fig. 1. Statistical comparisons of effects of soft-, white-, and brown-rot fungi on various wood species.

TABLE 1. Weight losses (%) caused by soft-rot fungi in sapwood of 15 species in a serial-block test[a]

Wood species (listed by common names, except *Eucalyptus* sp.)	Soft-rot fungi							Overall average weight loss by wood species (%)
	Mesophiles			Thermophiles				
	Papulospora sp.	*Monodictys* sp.	*Graphium* sp.	*Dactylomyces crustaceous*	*Allescheria* sp.	*Penicillium* sp.	*Thielavia terrestris*	
Douglas-fir	0.6	1.2	2.1	0.0	2.5	0.0	0.8	1.0
Engelmann spruce	5.9	6.4	5.6	2.8	4.0	4.6	6.9	5.2
Western white spruce	7.2	3.3	4.0	3.0	6.2	5.0	2.7	4.5
Sitka spruce	6.5	4.3	2.4	4.0	8.1	2.7	2.2	4.3
Ponderosa pine	12.6	4.0	3.2	0.7	6.0	1.6	1.8	4.3
Western white pine	12.8	4.4	4.0	5.9	8.4	8.0	6.8	7.2
Lodgepole pine	9.0	3.6	3.5	3.6	8.4	5.6	5.3	5.6
Southern pine	4.2	5.9	4.1	4.5	4.3	4.4	3.9	4.5
Red pine	4.0	5.8	2.1	3.0	3.6	3.7	3.5	3.7
Western hemlock	3.9	2.6	2.6	3.1	2.4	2.3	2.0	2.7
Western red cedar	0.4	2.6	1.1	1.5	0.3	0.7	0.8	1.1
Redwood	4.1	5.2	4.6	3.7	4.1	4.0	4.2	4.3
Balsam poplar	16.7	20.9	23.7	5.4	37.8	37.0	17.4	22.7
Eucalyptus sp.	12.2	23.0	22.9	11.2	24.3	18.1	15.6	18.2
Red alder	10.9	27.4	32.4	2.1	34.8	34.0	21.6	23.3
Overall avg weight loss caused by fungal spp.	7.4	8.0	7.9	3.6	10.3	8.8	6.4	

[a]Data are maximum weight losses in four replicates.

1). The respective means are ranked from lowest (left) to highest (right) and those which show no differences are connected with a line. Successive lines show additional nonsignificant groupings. For example, weight losses produced by *D. crustaceous* (DC) in *Eucalyptus* sp. (E) are significantly higher than the others; Douglas-fir (DF) through southern pine (SP) do not differ; and western red cedar (WR) through white pine (WP) are not different.

Most fungi caused significantly higher decay in one or more hardwood species than in any of the softwoods. Significance of differences between softwoods varied according to the test fungus used (Fig. 1).

For each wood species, weight losses caused by the different fungi were compared. Significant differences in these weight losses occurred only in ponderosa pine and the three hardwoods. In the pine, *Papulospora* sp. caused significantly higher losses than did *D. crustaceous*, *Penicillium* sp., and *T. terrestris*. However, in red alder, *Papulospora* sp. together with *D. crustaceous* were responsible for lowest weight losses incurred. *Penicillium* sp. and *Allescheria* sp. caused significantly higher weight losses in balsam poplar while *D. crustaceous* again was lowest in decay capability. Failure to induce significant weight losses (significant from zero) occurred with only two of the test woods, namely Douglas-fir and western hemlock.

TABLE 2. Weight losses (%) caused by white-rot fungi in sapwood of 15 species in an agar-block test[a]

Wood species (listed by common names, except *Eucalyptus* sp.)	White-rot fungi					Overall average weight loss by wood species (%)
	Coriolus versicolor	*Phanerochaete chrysosporium*	*Lentinus tigrinus*	*Ganoderma applanatum*	Unknown (ME-485)	
Douglas-fir	16	5	7	8	10	9.2
Engelmann spruce	20	2	11	N.T.[b]	21	13.5
Western white spruce	18	0	8	9	16	10.2
Sitka spruce	11	0	9	8	20	9.6
Ponderosa pine	4	0	11	10	17	8.4
Western white pine	19	5	17	19	24	16.8
Lodgepole pine	34	15	16	16	28	21.8
Southern pine	16	3	10	14	21	12.8
Red pine	27	1	22	16	31	19.4
Western hemlock	7	0	6	7	17	7.4
Western red cedar	21	0	10	N.T.	21	13.0
Redwood	17	0	9	17	18	12.2
Balsam poplar	46	13	22	22	18	24.2
Eucalyptus sp.	59	18	18	27	8	26.0
Red alder	51	12	24	26	18	26.2
Overall avg weight loss caused by fungal spp.	24.4	4.9	13.3	15.3	19.2	

[a]Data are averages of six replicates.
[b]Abbreviation N.T. = not tested.

TABLE 3. Weight losses (%) caused by brown-rot fungi in sapwood of 15 species in an agar-block test[a]

Wood species (listed by common names, except *Eucalyptus* sp.)	Brown-rot fungi				Overall average weight loss by wood species (%)
	Gloeophyllum saepiarium	*Poria placenta*	*Gloeophyllum trabeum*	*Lentinus lepideus*	
Douglas-fir	23	43	21	30	29.3
Engelmann spruce	32	41	N.T.[b]	N.T.	...
Western white spruce	31	38	22	23	28.5
Sitka spruce	27	29	18	25	24.8
Ponderosa pine	27	47	24	27	31.3
Western white pine	29	37	22	37	31.3
Lodgepole pine	34	48	24	45	37.8
Southern pine	21	30	23	26	25.0
Red pine	45	45	26	35	37.8
Western hemlock	20	26	16	25	21.8
Western red cedar	28	48	N.T.	N.T.	...
Redwood	12	39	13	20	21.0
Balsam poplar	31	49	30	32	35.5
Eucalyptus sp.	0	0	1	0	.3
Red alder	1	27	25	16	17.3
Overall avg weight loss caused by fungal spp.	24.1	36.5	20.4	26.2	

[a]Data are averages of six replicates.
[b]Abbreviation N.T. = not tested.

The overall average of the weight losses (OAWL) caused by all of the soft-rot fungi in each wood species was determined, providing a measure of the resistance of the wood to the entire range of soft-rot fungi (Table 1). A measure of the relative importance of each of the test fungi is provided as OAWL by fungal species in Table 1. No statistical assessment of these data was possible because of unequal variances.

White-rot and brown-rot tests.—The average weight loss was calculated for each set of six blocks exposed to white-rot fungi (Table 2) and to brown-rot fungi (Table 3).

For each fungus the weight losses caused in the various woods were compared statistically (Fig. 1). *Eucalyptus* sp. was significantly more susceptible to decay than the bulk of the other woods tested, as caused by all white-rot fungi except the unknown isolate, ME-485. In the case of the latter fungus, as well as in that of all of the brown-rot fungi, *Eucalyptus* sp. was decayed significantly less than most other woods. Significantly greater decay (weight loss) was encountered in red and lodgepole pines, than in most other test woods, when exposed to the brown-rot fungi *G. saepiarium* and *L. lepideus* (Fig. 1).

For each wood species, weight losses caused by the different fungi also were compared. With respect to the white-rot fungi, *P. chrysosporium* caused significantly less decay than the other fungi on all test woods except Douglas-fir, lodgepole pine, and *Eucalyptus* sp. On the other hand, *C. versicolor* and/or the unknown white-rot fungus (ME-485) caused significantly greater decay than the other fungi in all test woods. Of the brown-rot fungi, *P. placenta* caused greatest weight losses in all but two woods (Table 3), but significantly greater losses than the other brown-rot fungi in only seven of the wood species. Least significant decay was caused by *G. saepiarium* in Engelmann spruce, western red cedar, and red alder, and by *G. trabeum* in lodgepole pine. No significant weight loss was incurred in *Eucalyptus* sp. by any of the brown-rot fungi.

The OAWL caused by all of the white-rot fungi in each wood species (Table 2) and similarly by the brown-rot fungi (Table 3) was determined to provide measures of the resistance of each wood to these fungal groups. Additionally, the OAWL by fungal species was calculated for both the white-rot (Table 2) and brown-rot fungi (Table 3). As was the case with the soft-rot tests, it was not possible to conduct a statistical analysis of OAWL data.

DISCUSSION

Comparison of results of stake (field) and laboratory natural decay resistance tests of the heartwood of different tropical woods (19) resulted in the establishment and definition of a decay resistance classification scheme based on weight losses encountered in laboratory tests:

Decay resistance class	Percent weight loss
Very resistant	0-10
Resistant	11-24
Moderately resistant	25-44
Nonresistant	45 or more

The soil-block method (1) is used in North America to obtain heartwood weight loss values necessary for classification of decay resistance of wood undergoing testing. The method is designed to bring about a minimum weight loss of 60% in nonresistant woods following their exposure for 12 weeks to pure cultures of decay fungi. It is considered a severe test, designed to simulate the high decay hazard conditions associated with contact of nontreated wood with moist soil.

Untreated sapwood, however, would be expected to be used only in above-ground situations where decay hazards were low. Hence, the methods of the present study provided for relatively slower rates of decay than the standard soil-block method (1). The difference in test methods used does not permit the insertion of our sapwood decay test results (weight losses) into the present natural decay resistance classification scheme. Additionally, the lack of field data on above-ground decay resistance of sapwood of different woods does not enable comparison of results of our laboratory tests with those of field tests; hence, parameters of sapwood decay classes cannot be ascertained, blocking the establishment of an independent sapwood natural decay resistance classification scheme at this time.

For purposes of comparison, however, we have arbitrarily separated weight loss values into the four groups A, B, C, and D, corresponding to categories of weight loss in the heartwood decay resistance classification (19); "A" = 0-10%, "B" = 11-24%, "C" = 25-44%, and "D" = 45% or more (Table 4).

Applying this scheme to serial-block tests with soft-rot fungi, all but two of the coniferous woods fall into group A (Table 4); ponderosa and western white pines fit into group B (Table 4) because weight losses due to decay by *Papulospora* sp. were 12.6% and 12.8%, respectively (Table 1). Balsam poplar and red alder fall into group C with weight losses in the 25% to 44% range, whereas the remaining hardwood, *Eucalyptus* sp., having undergone a maximum weight loss of 24% falls into group B (Tables 1, 4).

Applying the above classification to decay caused by the white-rot basidiomycetes in agar-block tests, all three hardwoods are in group D (Table 4) because of the weight losses caused by *C. versicolor* (Table 2). Lodgepole pine and red pine fall into group C, and all remaining softwoods fit into group B (Table 4).

When the brown-rot fungi were used in similar decay tests, only *Eucalyptus* sp. fell into the most resistant group (Table 4). Ponderosa pine, lodgepole pine, red pine, western red cedar, and balsam poplar proved least resistant (group D), and the remaining wood species were only slightly more resistant (Table 3). Brown-rot was much more severe and more uniform among species than had been found by Hubert (10).

In the overall separation of test woods into decay resistance groups, we find (Table 4) that, as the basis for classification changes from soft-rot to white-rot and finally to brown-rot test fungi, the majority of the woods decreased in decay resistance by one group. Hence, when brown-rot fungi were utilized as test organisms, all woods but *Eucalyptus* sp. were in the two least resistant group. This is to be expected where the bulk of the woods are softwoods, generally considered to be more susceptible to attack by brown-rot fungi than by soft-rot or white-rot fungi.

Soft-rot fungi have the reputation of being able to decay hardwoods at a much faster rate than softwoods (5, 12). Preference of soft-rotters for hardwoods has been attributed to differences in amount and type of lignin between gymnosperms and angiosperms, and to differences in the structure of their cell walls (12). Though much of this is based on tests involving heartwood only, Liese's (12) few species and those involved in the present study bear out the theory that the hardwood sapwood is generally more susceptible to soft-rot attack than coniferous sapwood. However, some deviations from the normal trend occurred: weight losses caused by *Papulospora* sp. in ponderosa and western white pines were not significantly different from that in *Eucalyptus* sp. and red alder (Fig. 1). *Dactylomyces crustaceous* produced minor weight losses in balsam poplar and red alder that were not significantly different from those produced in most of the softwoods; however, this fungus caused significantly higher weight loss in *Eucalyptus* sp. than in any of the other wood species (Fig. 1). Investigation of these anomalies could widen our knowledge of factors affecting wood decay.

As has been often reported (6, 15, 16), the white-rot fungi (except isolate ME-485, the unknown basidiomycete) showed a preference for hardwoods. The unknown basidiomycete caused as much or more weight loss in eight of the 12 softwoods than it did in balsam poplar, the most decay-susceptible hardwood. Decay was significantly greater, however, in only three of the eight softwoods — in western white, lodgepole, and red pines (Fig. 1). The brown-rot fungi, by contrast, did not show a preference for hardwoods or softwoods, although these fungi are most often associated with decay in softwood structures (6). This agrees with earlier laboratory decay tests (9, 16, 23) in which brown-rot fungi produced substantial decay in both softwoods and hardwoods. Because no brown-rot fungi were able to cause significant weight loss in *Eucalyptus* sp. (Table 3), this wood is a prime candidate for inclusion in studies to elucidate fungal preferences for either hardwoods or softwoods.

It has been postulated that variation in decay susceptibility of woods containing little or no fungitoxic extractives was due to amount of nitrogen (N) in the wood. This was substantiated when a positive relationship was shown between N content of wood and susceptibility to decay by *G. trabeum* and *C. versicolor* (14). Reis (17, 18) found sapwood decay susceptibility within Brazilian species was directly related to their N content; however, no such correlation was noted when these species were considered together. This will be investigated further through N analyses of the woods used here.

To determine whether longevity of sapwood of different woods, utilized above-ground, can be estimated from their placement in sapwood decay resistance classes, samples of each tree species have been placed in above-ground field tests. Information from these tests will determine whether a correlation exists between actual

TABLE 4. Decay resistance grouping[a] of sapwood of 15 wood species (listed by common names, except *Eucalyptus* sp.)

Classification basis	Decay resistance groups			
	A (Most resistant)	B	C	D (Least resistant)
Resistance to soft-rot attack (serial-block method)	Douglas-fir Engelmann spruce Western white spruce Sitka spruce Lodgepole pine Southern pine Red pine Western hemlock Western red cedar Redwood	Ponderosa pine Western white pine *Eucalyptus* sp.	Balsam poplar Red alder	...
Resistance to white-rot attack (purified agar-block method)	...	Douglas-fir Engelmann spruce Western white spruce Sitka spruce Ponderosa pine Western white pine Southern pine Western hemlock Western red cedar Redwood	Lodgepole pine Red pine	Balsam poplar *Eucalyptus* sp. Red alder
Resistance to brown-rot attack (purified agar-block method)	*Eucalyptus* sp.	...	Douglas-fir Engelmann spruce Western white spruce Sitka spruce Western white pine Southern pine Western hemlock Redwood Red alder	Ponderosa pine Lodgepole pine Red pine Western red cedar Balsam poplar

[a]Based on weight losses obtained in nonground contact decay tests.

service life and laboratory-determined decay resistance.

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