Research Note

Resistance of 22 Southern Hardwoods to Wood-Decay Fungi and Subterranean Termites

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ABSTRACT. Of 22 hardwood species growing on southern pine sites, blackjack, white, and post oaks proved most resistant to attack by the brown-rot fungus, *Lenzites trabea*. The amount of decay ranged from 8 percent for blackjack and white oak to 67 percent for red maple. Winged elm, yellow-poplar, and post, black, white, and southern red oaks were the most resistant to attack by the eastern subterranean termite, *Reticulitermes flavipes*. After 8 weeks, less than 1 percent of the termites survived on post oak and winged elm; but 72 percent survived on hackberry, the most susceptible species. The amount of wood eaten ranged from 131 mg for winged elm to 530 mg for hackberry. The oaks as a group appeared to be relatively resistant to both termites and decay fungi in our laboratory tests.

MOST OF THE 54 BILLION FT.[3] of hardwoods growing on southern pine sites (9) have been considered worthless because they are small-diameter, poor-quality trees. Now, however, efforts are underway to utilize this resource, and studies are being done to investigate the potential use of this wood in composite products. The anatomical, physical, and chemical properties of the wood are being determined for 22 species which comprise more than 95 percent of the hardwood volume on pine sites and have a total volume approaching that of the pines (8). Wood from the same trees was evaluated for natural durability in the present study. Decay resistance was tested by exposure to *Lenzites trabea* Pers. ex Fr.; termite resistance was determined by survival and feeding responses of the native subterranean termite, *Reticulitermes flavipes* (Kollar), on these woods.

Methods and Materials

Test Organisms

Externally undifferentiated termites beyond the third instar were selected from *R. flavipes* colonies that had been collected in the field and maintained in segments of the colonized logs in the laboratory. The brown-rot fungus, *L. trabea,* was used to evaluate decay resistance because it commonly causes decay of wood exposed above ground an subjected to intermittent wetting. Composi wood products made from hardwoods woul likely be used in aboveground areas.

Wood Samples

Samples were taken from either 9 or 1 trees in each of the 22 hardwood speci (Table 1). Only trees 6 inches in diameter breast height (DBH) were selected because th greatest volume of pine-site hardwoods occu in the small-diameter classes. The average a for all trees was 39 years (the range was fro 27 years for yellow-poplar to 59 years for blac tupelo). Each tree in a species was obtaine from a different site, and the samplin locations were broadly distributed throughou that portion of each species' range occurrin in the South (8).

Disks about 5 cm thick were cut from th sample trees at 6 feet above the ground; the

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TABLE 1. — *Hardwood species tested for termite and decay resistance.*

Scientific name	Common name	Code
Acer rubrum L.	Red maple	
Carya spp.	Hickory, true	
Celtis spp.	Hackberry	
Fraxinus americana L.	White ash	
F. pennsylvanica Marsh.	Green ash	GA
Liquidambar styraciflua L.	Sweetgum	SG
Liriodendron tulipifera L.	Yellow-poplar	YP
Magnolia virginiana L.	Sweetbay	SB
Nyssa sylvatica Marsh.	Black tupelo	BT
Quercus alba L.	White oak	WhO
Q. coccinea Muenchh.	Scarlet oak	ScO
Q. falcata Michx.	Southern red oak	SRO
Q. falcata var. *pagodaefolia* Ell.	Cherrybark oak	ChO
Q. laurifolia Michx.	Laurel oak	LO
Q. marilandica Muenchh.	Blackjack oak	BjO
Q. nigra L.	Water oak	WaO
Q. rubra L.	Northern red oak	NRO
Q. shumardii Buckl.	Shumard oak	ShO
Q. stellata Wangenh.	Post oak	PO
Q. velutina Lam.	Black oak	BO
Ulmus alata Michx.	Winged elm	WE
U. americana L.	American elm	AE

60° wedges were taken from the disks and air-dried. Test blocks (2.0 by 2.0 by 0.9 cm) were cut from the outer heartwood portion of each wedge with the 0.9-cm dimension parallel to the grain (Fig. 1). When the wedges were too small or the heartwood zone too narrow, as in white and green ash, blocks were cut to include as much heartwood as possible. Blocks were cut from the inner one-third of wedges without visible heartwood.

Decay Test

Soil-block decay chambers were prepared according to the ASTM standard (1) with modifications. Eight-ounce French square bottles (clear glass) served as decay chambers. Feeder strips were cut from 0.3-cm rotary cut veneer of fresh slash pine sapwood *(Pinus elliottii* Engelm. var. *elliottii).* Decay chambers were autoclaved for 30 minutes at 15 psi on two consecutive days to insure sterility of the soil; enough distilled water was added to each chamber to bring the soil to 130 percent of its water-holding capacity after sterilization.

One weighed block from each wedge was tested. Reference blocks with the same dimensions were cut from a board of sweetgum sapwood (1). The use of a smaller block than indicated in the standard was necessitated by

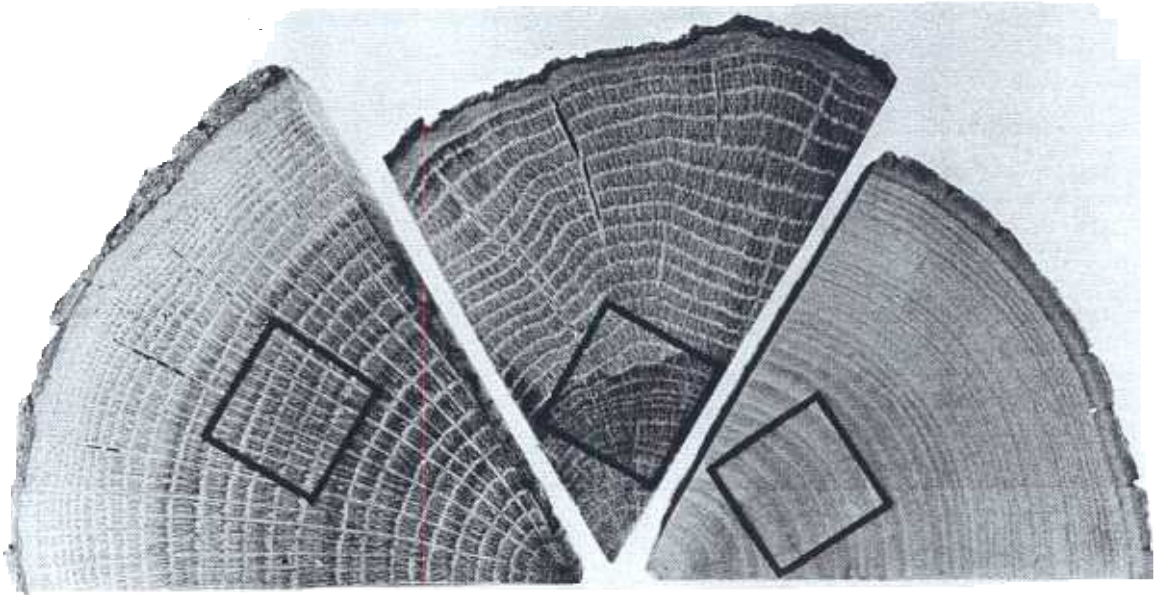

Figure 1. — Wedges indicating location of test blocks with respect to heartwood. Left, white oak with abundance of heartwood. Center, water oak with heartwood zone too narrow to include entire block. Right, green ash with no visible heartwood.

the size of the wedges. Incubation was terminated when the weight losses of the reference blocks reached about 60 percent. The percent weight loss of test blocks was the measure of wood decay susceptibility.

Termite Tests

Plastic containers 5.0 cm in diameter by 3.5 cm high were packed with 50 g of sterile sand moistened with distilled water to maintain relative humidity near saturation. One weighed test block was placed on the surface of the sand, and 100 termites were added to each container. Duplicate tests were run for each tree. The containers were placed in an incubator at 25°C for 8 weeks, but visual observations were made weekly to determine termite survival. After 8 weeks, the live termites were counted, and the wood blocks were dried and reweighed to obtain an estimate of the amount of wood eaten. Loss in equilibrium weight of test blocks after 8 weeks' exposure to termites was the index of feeding preference.

Data Analysis

The data were analyzed by an analysis of variance. Decay and termite survival data were transformed to arc sine for analysis, but to facilitate interpretation they are presented as retransformed values in the tables. Differences in decay and in termite feeding and survival were compared at the 0.05 level by Duncan's multiple range test.

TABLE 2. — *Wood species ranked by Duncan's multiple range test[a] to indicate extent of wood decay, force-feeding preferences of termites, and termite survival on test woods.*

Species	Decay[b]	Species	Wood eaten	Species	Termite survival at 8 weeks[b]
					Percent
BjO[c]		WE		PO	<1
WhO		PO		WE	<1
PO[c]		YP		BO	2
Hi[c]		BO		WhO	2
LO		WhO		SRO	4
BO		SRO		BjO[c]	7
SRO		NRO		YP	10
WA[c]		ShO		AE	16
WaO		ScO		NRO	17
GA		AE		Hi	17
ShO		ChO		SB[c]	22
NRO		LO		BT	23
ScO		BjO[c]		LO	25
WE		Hi		ScO	30
ChO		SB[c]		ShO	31
AE		BT		WaO	31
SG		SG		GA	32
YP		WaO		ChO	32
BT		GA		SG	34
Ha		WA		WA	35
SB[c]		RM		RM	38
RM		Ha		Ha	72

[a]Ranked from most resistant to most susceptible; means connected by a line are not significantly different at the 0.05 level of probability.
[b]Decay and termite survival data were transformed to arc sine for analysis but are presented as retransformed data in the table.
[c]Nine rather than 10 trees tested.

Results and Discussion

Decay Test

In several cases, wood from the small-diameter, slow-grown, and often poorly formed trees sampled on southern pine sites proved more resistant to decay than sawlog-size trees of the same species. The heartwood of white oaks is considered resistant to very resistant; that of red oaks, hickory, and green ash is described as slightly resistant to nonresistant (6, 13, 14). However, in our test blackjack oak, a member of the red oak group, and white and post oaks had the lowest weight losses—less than 10 percent (Table 2). Hickory, white ash, green ash, and the red oaks—laurel, black, southern red, and water—had weight losses of only 20 to 31 percent. Three other red oaks and winged elm lost 36 to 40 percent of their weight but did not differ significantly from the 20 to 31 percent group except for hickory. The species shown to be least resistant were sweetgum, yellow-poplar, black tupelo, hackberry, sweetbay, and red maple. The ASTM (1) classifications of highly resistant (weight loss of zero to 10 percent), resistant (11 to 24 percent), moderately resistant (25 to 44 percent), and nonresistant (45 percent or greater) could not be fitted to our data because groupings based on statistical significance crossed the classification divisions.

Termite Tests

Although few commercial timbers of the United States are considered resistant to termite attack (15, 16), not many native hardwoods have been tested. In our test hackberry was the only wood of which more than 500 mg were eaten and on which more than 50 percent of the termites survived for 8 weeks (Table 2). Of the nonoak species winged elm and yellow-poplar were the most

resistant to attack by termites. Of the 11 species of *Quercus* tested, 10 were among the 13 species with the least wood eaten. The most susceptible of the oaks was water oak, but feeding on it did not differ significantly from that on blackjack, laurel, cherrybark, scarlet, shumard, and northern red oak. Less than 10 percent of the termites survived on the two white oaks (white and post) and on the three red oaks (black, southern red, and blackjack). Most of the wood species, when ranked by survival and amount of wood eaten by *R. flavipes*, fell generally into broad, overlapping groups (Table 2).

Decay Versus Termite Tests

Two species — post and white oaks — were quite resistant to both decay fungi and termites; two species — red maple and hackberry — were susceptible to both (Table 2). The other species showed little relationship in their resistance to the test organisms. For example, blackjack oak was the most resistant to decay, but its mean weight loss to termites was 317 mg. In contrast, winged elm and yellow-poplar were quite resistant to termites but were susceptible to decay (Table 2).

Wood Properties and Potential Use

Some timbers are well known for their resistance to attack by insects and decay organisms. This natural durability results primarily from the extractive constituents of the heartwood (5, 10, 11, 12, 14, 16). Because these constituents are not distributed evenly within the heartwood, its durability can be affected by such factors as the age of the tree, the conditions under which it was grown, and the part of the tree from which it was cut. The durability of the outer heartwood increases with tree age (4, 7, 14), and slow-grown trees produce a smaller volume of nondurable, immature wood near the pith than fast-grown trees. Thus, the small-diameter, relatively old trees used in this study probably contain a larger proportion of durable heartwood than trees of the same species normally considered to be of merchantable size.

In conclusion, the potential is good for utilizing these woods in such products as wood particleboards. The susceptibility of unprotected particleboards to termite attack depends upon the wood species used (2). Tests by Behr and Wittrup (3) indicated that particleboards made from decay and termite-susceptible wood such as jack pine sapwood can be protected by including flakes of resistant redwood or northern white cedar heartwood. In our laboratory test, the oaks as a group (in particular, the white oaks) appeared to be fairly resistant to both termites and decay fungi. Perhaps a proportion of oak chips or flakes to other species could be determined that would increase the finished product's resistance to biodegradation.

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