Wood and Decay – Wood Preservation for Fresh Water Uses
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WOOD PRESERVATION FOR FRESH WATER USES

WOOD AND DECAY

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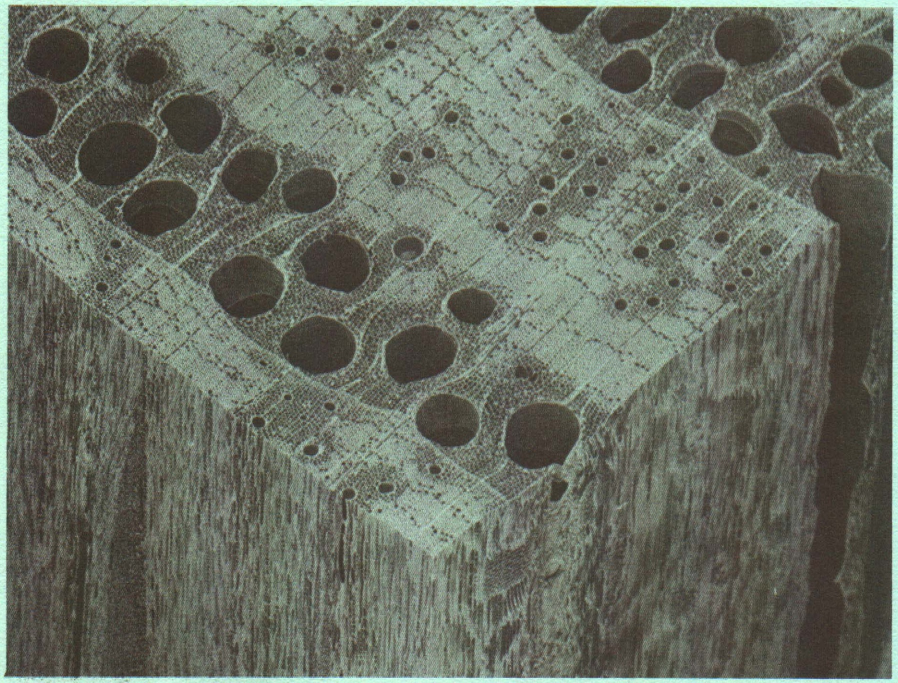
INTRODUCTION

MARINAS, DOCKS, WHARVES and other wooden structures encircle the Great Lakes. Wood exposed to constant dousing is very vulnerable to decay. Consider wood preservation when building wooden structures to use near fresh water.

The four publications in this series describe fungi and insects that attack wood, and they provide information on preservatives and their application and how to use treated wood.



Red oak, highly magnified, a hardwood with a variety of cell types.
(N.C. Brown Center for Ultrastructure Studies, College of Environmental Science and Forestry, SUNY)

STRUCTURE AND PROPERTIES

TO UNDERSTAND HOW wood preservatives work, and problems in treating wood, you need some familiarity with structure, properties and nomenclature of wood.

Hardwoods come from broad-leaved trees like oak, ash or maple. The actual wood of the tree may be hard or soft. Hardwoods are used for boat trim and sometimes for piling, ferry slips, fenders and the like, but not usually for construction.

Softwoods are cut from cone or needle bearing trees like pines, cedar, redwood or Douglas fir. The wood from some varieties like cedars is soft while larch wood may be quite hard. Softwoods are most often used for construction and treated with preservatives.

How Wood is Formed

In temperate climates like Michigan, trees form rings as they grow. These rings are exposed when the tree is cut down. Each ring usually represents 1 year's growth. The inner part of the ring is springwood and the outer part is summerwood. Hardwoods like oak, elm and ash have large pores in springwood but those like beech, birch and basswood do not have a distinct difference between spring and summerwood. Summerwood in many softwoods is a distinct band of thick walled cells much harder than springwood. Summerwood is more prominent in southern pines or Douglas fir than in white pine or cedars.

Many tree species have a distinct area of darker-colored wood, the heartwood, in the center of the trunk. A lighter-colored band, the sapwood, separates the heartwood from the bark (Fig. 1). Among softwoods, Douglas fir and the pines have distinct heartwood. Softwoods having no distinct heartwood include spruces and true fir. Some heartwoods are naturally decay-resistant; for example, redwood and cedars. No sapwoods have natural decay resistance.

Grain is the direction parallel with the trunk length of a tree or the long dimension of typical boards.

Fine Structure of Wood

Wood consists of millions of cells. Cell structure is the most important factor in how well wood will take up preservative. The original contents of the cells died and disappeared after the cell was formed (Fig. 2). Thus, wood is largely a dead material even when in a standing tree. Only the outer few growth rings contain living cells. The predominant direction of the long dimension of cells is the grain direction (Fig. 3).

Wood Moisture

Wood cut from a living tree has a high moisture content. Many species contain more water than solid wood when first cut. To preserve wood, much of this moisture must be removed. Lumbermen dry wood naturally with air or in a kiln.

Wet wood is not as strong as dry wood. Below 28% moisture, as wood loses water it increases in strength. Also, wood shrinks as it dries. The maximum moisture content is stamped on graded lumber.

Wood Permeability

Because wood is porous, it should soak up liquids readily, but some woods cannot be penetrated by pressures of 200 pounds per square inch (PSI) and more. In fact, more woods are difficult to penetrate than easy to treat. With few exceptions, therefore, wood preservation is best left to plants equipped to do this kind of work.

Its microscopic structure makes wood difficult to treat. The minute openings between cells or the cells themselves are closed or plugged.

Thin, oily liquids like paint thinner appear to enter wood when dropped on it. Actually, the liquid merely spreads over the surface if the wood is poorly permeable.

Why Wood Deteriorates

No construction material is immune to deterioration. Metals corrode, glass shatters, and concrete cracks. Wood may decay or insects can attack it. Several marine borers destroy wood, but these occur only in salt or brackish water. Wood is vulnerable to decay when moisture content is above 25%. Insects may attack dry as well as wet wood.

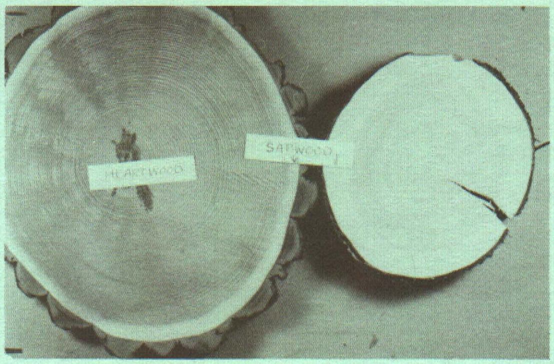


Fig. 1. Cross-sections of hardwood (left) and softwood (right) logs showing sapwood and heartwood. Annual growth rings are distinct on hardwood heartwood.

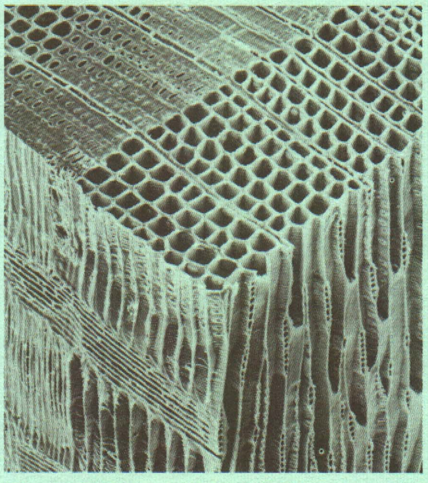


Fig. 2. Highly magnified (100X) view of a softwood. Note length of cells compared with width. Grain direction vertical. Summerwood cells with thick walls. (Photo courtesy N.C. Brown Center for Ultrastructure Studies at College of Environmental Science and Forestry, SUNY.)

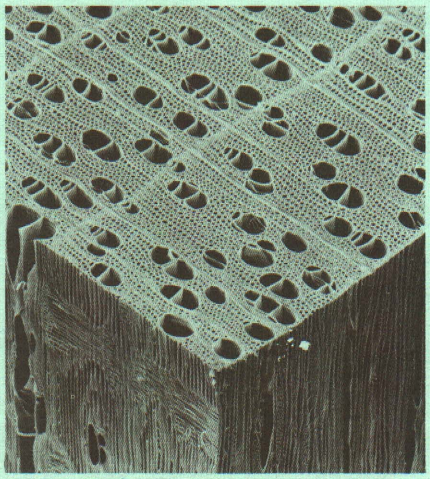


Fig. 3. Hardwood highly magnified. Greater variety of cells than in softwood. Large cells are water-conducting vessels. (From Core, Côte and Day, Wood-Structure and Identification, by permission Syracuse University Press.)

Wood is composed of cellulose, lignin, hemi-celluloses and extractives — polymers produced by the growing tree. These natural polymers provide fungi and insects with materials they need for growth.

Decay and weathering frequently cause deterioration in wood used outdoors. Weathering is largely a surface condition. Decay usually penetrates deeply and causes great strength loss. Accordingly, decay is important in structures. Weathering would worry boat owners or users where appearance counts.

DECAY

Brown and White Rotters

Most wood decay is caused by fungi (fungus, singular). They are related to the common edible mushrooms and some might be mistaken for them. The "mushroom" fruiting body or "conk" of a fungus bears thousands of spores, resembling seeds in more advanced plants. Mature spores grow on any moist wood. They are readily dislodged when people, animals or birds contact the fruiting body (Fig. 4). Animals, insects or air currents carry spores that are transferred to other wood. Because decay fungus spores are everywhere, no wood is safe from decay if other conditions are right (Fig. 5).

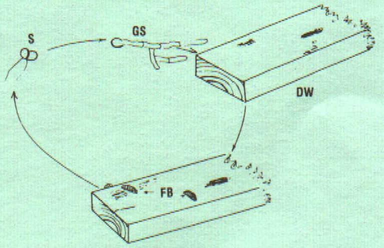
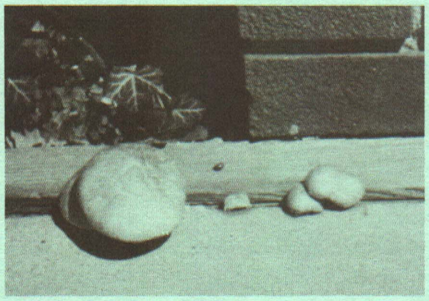


Fig. 4. Stages in spread of decay. Spores (S) are produced in fruiting body (FB) growing on decayed wood. Spores are blown to moist wood and germinate (GS). Wood decays (DW). When wood is heavily rotted, fruiting bodies appear (FB).



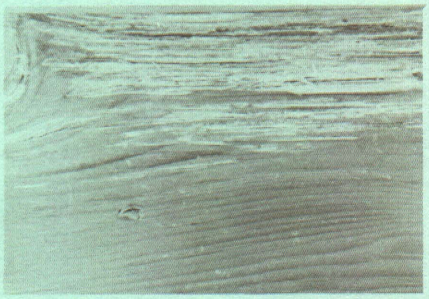


Fig. 5. (Left) Fruiting body resembling a mushroom growing from wood that appears sound on the surface but is decayed within. Fig. 6. (Center) Deck boards decayed by brown rot. Fig. 7. (Right) White rotted wood.

When the moisture content of wood is about 25-30% (possibly 20%, for some imported woods), spores germinate and form cell strands visible only by high magnification. These cells *(hyphae)* grow into and through wood.

Decay fungi excrete enzymes that dissolve holes through wood cells, using up wood substances and weakening it. Fungi specialists recognize brown and white rotters. Brown rotters attack cellulose more than lignin, and cause rapid loss of wood strength (Fig. 6). White rotters attack both lignin and cellulose but at a slower rate than brown rotters. Whitish spots or streaks are sometimes left in the wood (Fig. 7).

During early stages of decay there is no visible change in color or appearance of other wood features. Later, however, the infected wood will lose some lustre and change color a bit. This is the incipient stage. It, too, may pass unnoticed especially on painted wood. Finally, decayed wood may crumble, shrink, absorb water, or change color. If painted, decayed wood may peel or crack. Strength is lost as well as weight. Fruiting bodies like mushrooms or conks may form, indicating advanced decay.

Dry wood will not rot, nor will it decay if kept submerged in water. Apparently, water doesn't provide enough dissolved oxygen for white or brown rotter growth. Microorganisms called **soft rots** can also decay wood even when submerged. These are described later.

Decay fungi grow best on wood at 76°-86°F (24°-30°C). Minimum temperature for growth is about 40°F (5°C). This explains why wood decays more slowly in the Great Lakes states compared to the Southeast. Even temperatures far below freezing will not kill decay fungi in wood; they become dormant.

However, a temperature of 140°F (60°C) for 4.5 hr will kill decay fungi in moist 2-in. pine. Although temperatures this high are common in summer at wood surface, they do not occur much below the surface. Do not rely on natural occurring high or low temperatures to kill decay in outdoor wood structures. Kiln drying is usually necessary to kill decay fungi (Table 1). However, lumber can be re-infected if not kept dry.

Table 1 — Recommended times for killing decay fungi in wood (temperature is that of interior of wood; wood heated in air)*

Relative humidity of heated air 90-97%		35-40%	
temp., °F	*time, min.*	*temp., °F*	*time, min.*
150	100		
		160	190
170	30	170	50
180	20		

From U.S. Forest Products Laboratory Technical Note 259

Soft Rots

Soft rots, another fungal group, attack wood differently from white or brown rots.

Soft rots grow slowly, largely confined to the outer surfaces to perhaps 1/16 in. until the rotten wood erodes. Then soft rots attack the underlying surface.

They do not form readily recognized fruiting bodies during advanced stages. When moist, wood attacked by soft rots is quite soft. When infected wood dries out, cross checks appear on the darkened decayed surface and the wood looks charred (Fig. 8).

Soft rots attack submerged wood or that kept wet by waves. Lake property owners should be especially interested in these fungi. Soft rots also decay wood in soil or wood frequently moistened by rain like the tops of posts or piles (Fig. 9).

Soft rots attack hardwoods more readily than softwoods. Thus, more and possibly different wood preservatives are needed to prevent soft rot

Fig. 8. Board surface destroyed by soft rot. Note small cross checks.

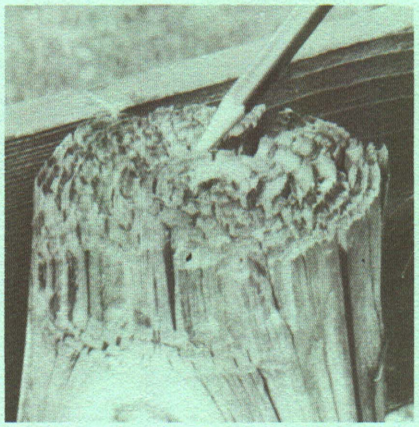


Fig. 9. Springwood portion of treated post eroded by soft rot.

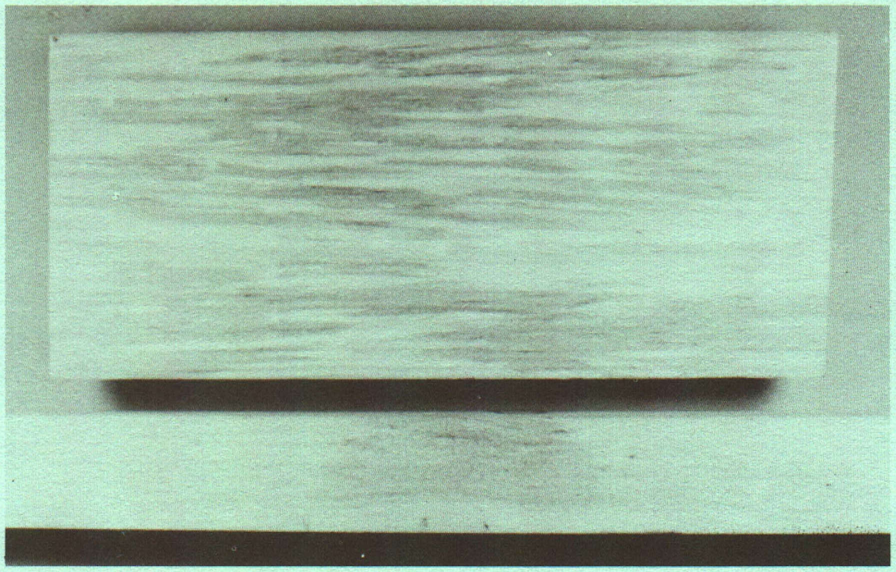


Fig. 10. Sap stain in pine boards. Dark color would show through on clear finish.

attack on hardwoods than on softwoods. With its high surface-to-volume ratio plywood is more readily attacked than solid wood.

Soft rots are more tolerant of higher temperatures and lower and higher moisture content than white and brown rotters.

Stains

Although not serious in structural wood, fungus stains are unsightly in trim woods. They disfigure light colored trim on boats, for example.

Most stains are gray to bluish gray and sometimes spotted with almost black streaks or spots. They are called either **blue** or **sap stains** because they are almost always confined to sapwood (Fig. 10). Because they use stored substances for growth rather than wood cell walls, they do little damage to wood strength, except possibly in shock resistance in heavily infected wood. Stain in clear-finished wood may mean moisture is entering through coating cracks or joints.

Stains could be a precursor of decay. Growth requirements are about the same as those of white or brown rots.

Insects

Beetles, termites, ants, wasps, bees, flies and moths attack wood. Only the first three are important near the Great Lakes. Insect damage to timber in waterfront structures is not nearly so great as that caused by fungi. Nevertheless, it can cost you money, so learn to recognize insects and how to prevent their damage.

Termites

The several types of termites are classified by where they live (Fig. 11). Only the subterranean (live below ground) type is important in the Great Lakes Region. Termites are abundant in lands bordering Lake Michigan and in parts of Michigan fronting on the Detroit River and Lake Erie. In Ohio, Pennsylvania and New York they are also found close to Lake Erie.

Subterranean termites prefer sandy soils and mild temperatures, both characteristics of areas near Lake Michigan. They do not, however, live in wet soils and would not be expected in beach and shore structures that are continuously wet. For example, a wooden dock would probably be termite-damaged only on the land end, well away from water.

Termites may elude you even though they are living in soil, sand or old stumps, particularly during prolonged dry spells. If you detect termite damage in driftwood, or wood scraps in or near beaches, chances are good that termites are active in the vicinity and will attack unprotected wood (Fig. 12).

You can recognize termite damage in wood by soil granular material, chewed wood and nondescript matter left in the tunnels and sometimes on the wood surface. Termite passageways break through soft parts of wood, leaving a number of thin "fingers" in the softwoods.

Shelter tubes built over the surface of wood, concrete, steel or other building material also indicate termites. Termites build inside concrete

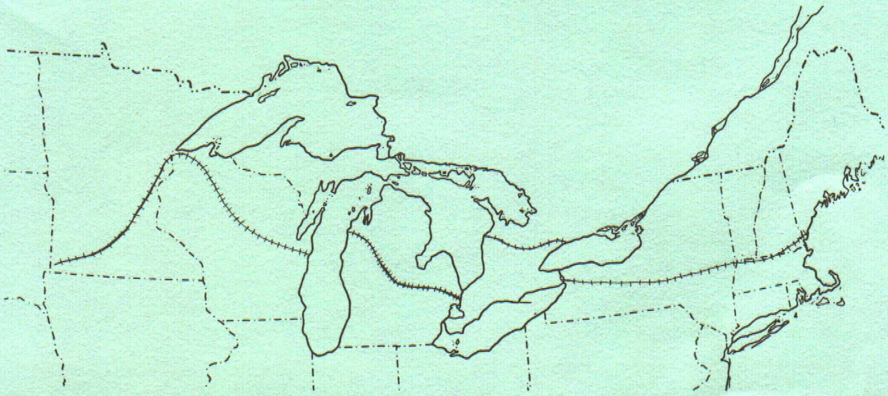


Fig. 11. Crossed line shows approximate northern limit of subterranean termites in Great Lakes area.

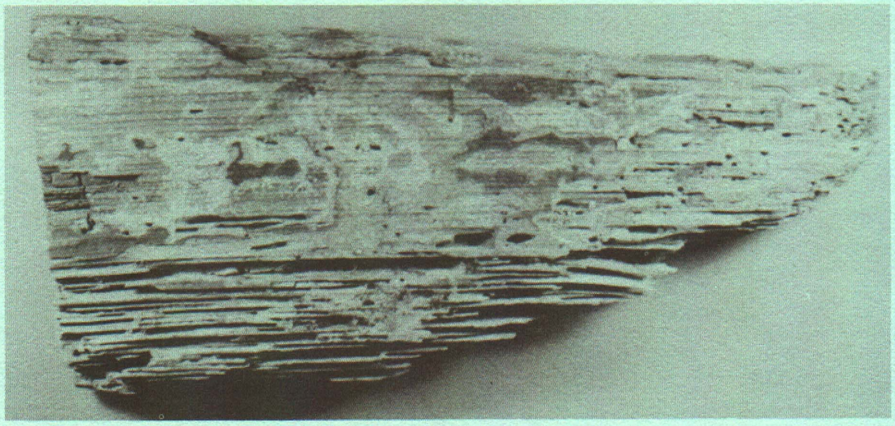


Fig. 12. (Left) Douglas fir plank damaged by termites. Note remaining harder summerwood and debris on surface and in excavated parts of wood. Fig. 13. (Right) Termite shelter tubes built over concrete block support under wood framed structure.

blocks, bricks, or stone piers and supports as well (Fig. 13). They travel between the underground nest and wood structures through the tubes.

Another way to determine termite damage is to find and identify the insects. However, about the only time termites are seen is when infested wood is accidentally broken or during the swarming period in May or June, generally in humid weather. Termites have no pronounced body constriction compared to ants, which are sometimes confused with termites. In addition, most termites are off-white, unless they have been eating dark wood. Ants are never so light (Fig. 14).

Most preservatives that prevent wood decay also prevent termite attack. To protect untreated wood, poison the soil around foundations or structural supports. Find out about insecticide recommendations and procedures in bulletins or books on termite control; or better, seek professional pest control help.

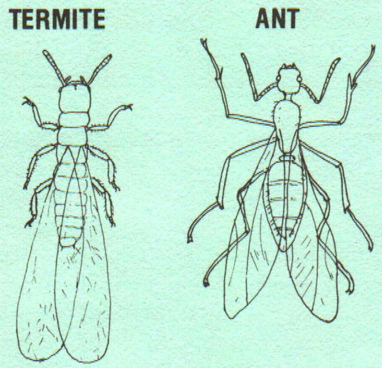


Fig. 14. Termite and ant compared. Note body constrictions of ant and angled antennae. Termites lose wings after a short mating period.

Beetles

Beetles attacking timber used in waterfront wood are generally placed in two groups. Some damage standing or recently felled trees or stored logs; the others attack lumber or timbers after these are installed (Figs. 15 and 16).

The first group hatches in wood and bores its way out, leaving ⅛- to ½-in. diameter holes packed with shredded wood. Most of these beetles cannot reinfest lumber cut from the log from which they emerged. Thus, except for holes left in the timber, these beetles do no further damage.

The other group, sometimes called powder post beetles, may reinfest wood and turn it into a powder which is pushed out of the emergence holes. Most of these beetles breed only in dry wood and would not bother wood in water. However, structures protected from water could be infested.

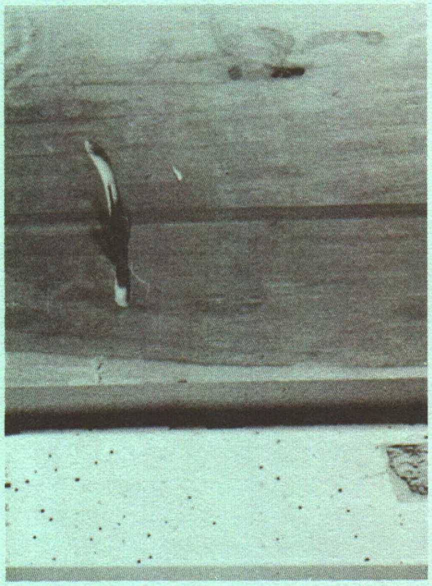


Fig. 15. Painted molding of banak heavily attacked by lyctus beetles. Board of western cedar with wood wasp damage and dead wasp in tunnel. Wasps attack wood in trees and not timber in use; lyctus does the opposite.

Fig. 16. Attack by larvae of long-horned beetles. Damage occurs in tree or log. Most of these beetles do not attack lumber in use.

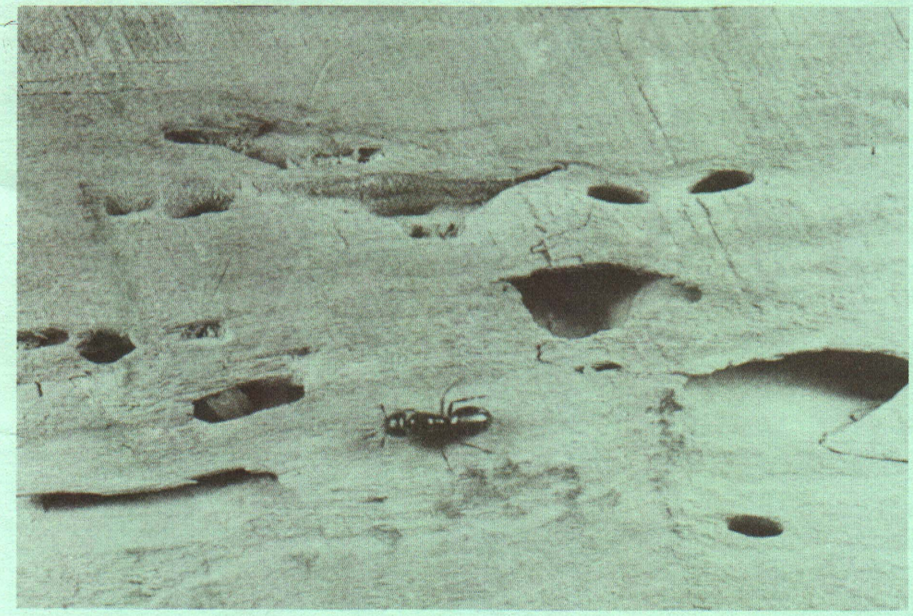


Fig. 17. Carpenter ant and cavities in wood chewed by this insect.

Beetles commonly damage sapwood of untreated hardwoods like elm, ash, oak and hickory. Preservative-treated wood should be safe from attack.

Carpenter Ants

Carpenter ants are large (1/4-1/2 in. long), dark brown or black insects. They nest inside decaying timbers and sometimes in sound wood. Although they excavate posts and timbers extensively, carpenter ants do not cause as much damage as termites (Fig. 17). Their presence sometimes indicates decay in structural wood. For this reason, inspect your structure to remove weakened timber. Treated wood will not be attacked unless it has lost enough preservative.

When large black ants are seen around wood structures, there is likely a nest near. The tunnels chewed into timber are clear and free of mud-like deposits in contrast to holes and tunnels of termite-damaged wood. In softwoods, the ants do not leave residues in tunnels as do termites.

Marine Borers

Many animals living in salt water attack wood, causing serious damage. Fortunately, shipworms, pholads and Liminoria cannot exist in the Great Lakes or upper St. Lawrence River. Occasionally, wood cut near salt water and rafted to the mill is attacked by shipworms (Fig. 18). Damage is exposed when wood is sawed into lumber or timber and sometimes mistaken for ongoing deterioration. Shipworms die when wood dries.

NATURALLY RESISTANT WOOD

An alternative to chemically treated wood is naturally resistant wood. Nature does not produce uniform trees for wood. This variability can work for you by learning what woods naturally resist decay and insects.

Durable and Nondurable Native Woods

Durable means having **more resistance** to biological **deterioration** (fungus and insect attack) than susceptible woods. It does not mean resistance to weathering, abrasion or physical force.

Sapwoods are nondurable. None resist the variety of decay fungi found in nature. The sapwood portion of logs or boards requires preservative treatment most. Sapwood thickness depends on kind of tree and its growth rate. For example, catalpa has only 1 or 2 growth rings of sapwood with a maximum of about 1/4 to 3/8 in. Ponderosa pine sapwood may be several inches thick when cut from large trees. The less sapwood, the less wood susceptible to decay.

No precise classification exists for decay resistance. Even within a single tree species resistance varies. However, average heartwood properties are considered in Table 2.

There are gradations of resistance between woods in a column. For example, red oak is more resistant than aspen; even so, it is not a resistant wood. In the resistant column, old growth (red heart) bald cypress is considerably more resistant than white oak, but both are more resistant than elm.

Variation in Natural Durability

We cannot yet control natural durability of wood. There is a range of decay and termite resistance between trees. The range can be so great that some trees, producing an otherwise durable wood, may be of low enough resistance to place them in the intermediate class.

Wood cut from outer heartwood is more resistant than that from the center of trees. The outer heartwood from the lower part of the tree is most resistant of all. Larger trees produce the most resistant outer heartwood.

Unfortunately, a user cannot buy only the most resistant wood since there is no quick, visual way to select it because of tree-to-tree variability. Boards cut from large trees differ from those of smaller trees because

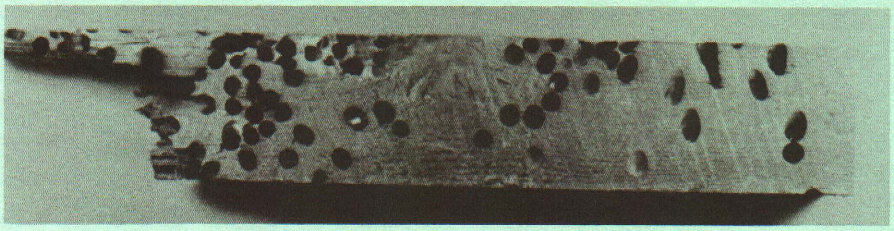


Fig. 18. Shipworm damaged wood cut from rafted logs.

the growth rings have less curvature. Choose boards from large trees, if possible, for uses where great decay or termite hazard exists.

Decay and insect resistance of woods is largely contributed by compounds called **extractives.** These compounds are not part of the wood structure and can be removed with solvents — a process called extraction. If soluble in cold water, wood could lose some extractives when exposed to wave action or submerged.

Comparative tests of decay resistance of naturally durable woods used in shoreline exposures are scanty. Table 3 lists the service life of some durable and nondurable wood exposed in the Canadian Great Lakes. This is not a controlled test and should not be used to predict life of woods shown. However, it offers a rough guide.

Natural Durability of Imported Woods

Most imported woods are brought into the country not for construction but for manufactured goods — furniture, cabinets, panelling, etc. Some are used for boat trim or hulls. Often, domestic treated wood is equally suited for a use and cheaper, too. There may be special cases, however, where imported wood is available at competitive cost. Table 4 presents resistance of the more frequently seen imported woods.

Table 2 — Decay resistance of domestic heartwoods

Resistant	*Intermediate*	*Not resistant*
Bald cypress (red heart)	Bald cypress (young growth)	Alder
		Ash
Catalpa	Douglas fir	Aspen
Cedars	Honey locust	Basswood
Junipers	Larch, western	Beech
Locust, black	Southern pines	Birches
Mesquite	Eastern white pine	Cottonwood
Mulberry, red	Tamarack	Elms
Redwood		Hemlocks
Walnut		Hickories
White oaks		Maples
Sassafrass		Red oak
		Pines (except as shown)
		Spruces
		Gums
		Sycamore
		Willow
		Yellow poplar

Table 3 — estimated service life of untreated wood used in structures in Canadian waters*

Item	*Wood*	*Location*	*Estimated Life, yr.*
Piling	Tamarack	Blind River — North Channel	11
Piling	Hemlock	Blind River, Lake Huron	11
Piling	White pine	Blind River, Lake Huron	11
Piling	Cedar	Blind River, Lake Huron	11
Piling	Western red cedar	Ganaoque — St. Lawrence R.	over 21
Stringers	Eastern white cedar	Bala, Lake Muskoka	17.5
Stringers	Eastern white cedar	Whitefish Falls, Georgian Bay	over 18
Stringers	Western red cedar	Gravenhurst, Lake Muskoka	16-18
Fenders	Maple	Manitoulin Is., Lake Huron	8.8
Fenders	White Pine	Manitoulin Is., Georgian Bay	8.3
Cribbing	Hemlock	Manitoulin Is., Lake Huron, Georgian Bay	8

* *(From Canada FPL Ottawa Mimeo 0-105-55)*

Table 4 — Decay resistance of imported woods

Resistant	*Intermediate*	*Not resistant*
Iroko	Apitong	Parana pine
Makore	African Mahogany	Virola
Teak	Lauan*	Lauan*
Mahogany	Keruing	Obeche
Jarrah	Meranti	Banak
Spanish cedar	Santa Maria	Limba
Angelique	Sapele	Cativo
Greenheart		Avodire
Utile		Ilomba
Afrormosia		Ramin

* *Name given to a wide range of species; some are not resistant.*

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