

Control of wood rot in waterfront structures

The struggle against wood deterioration dates back to humanity's first use of wood for tools, shelters, and boats.

For over 2,000 years people have recognized the need to keep wood dry, to place it properly in structures, and to find remedies against its infirmities.

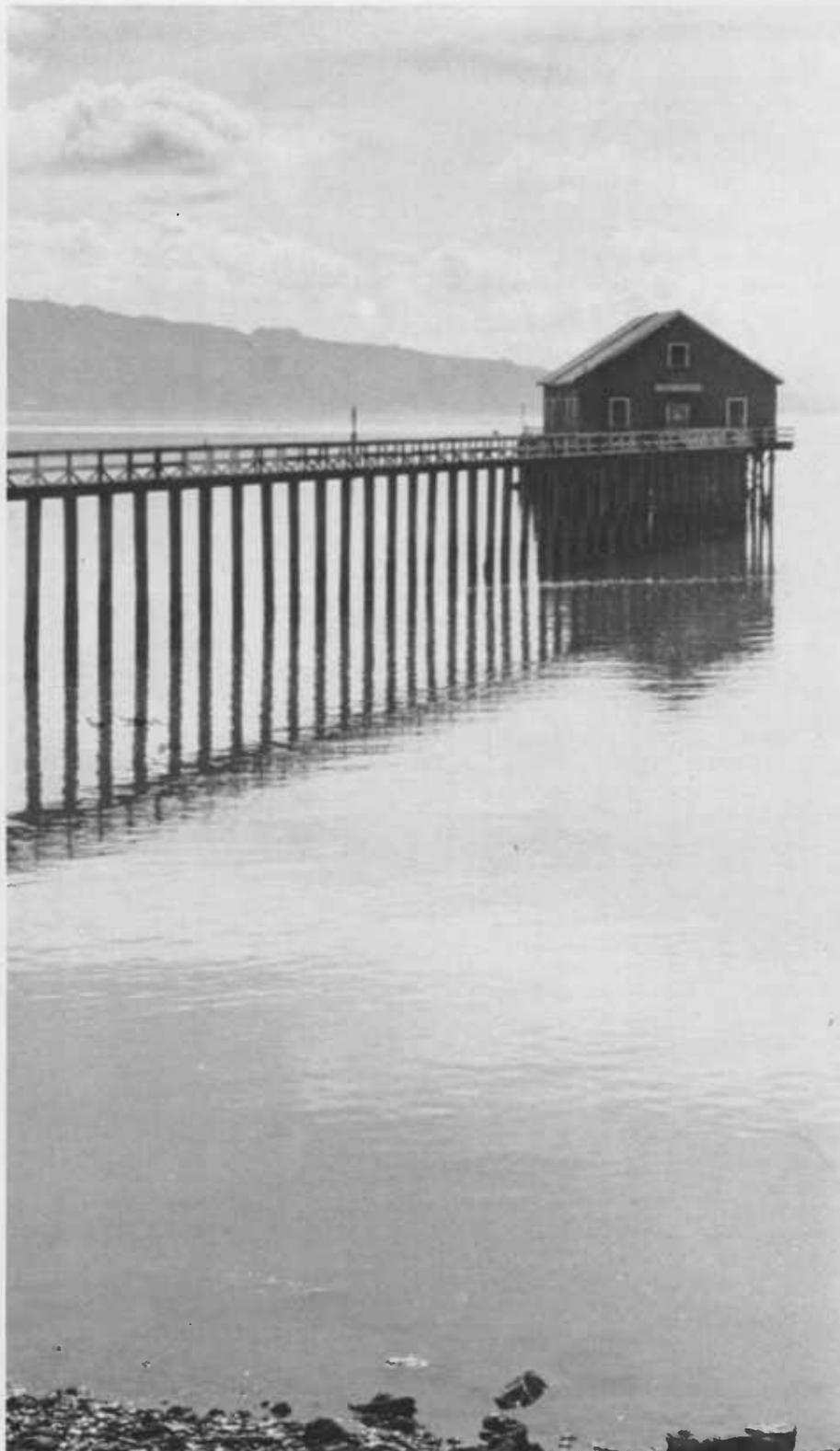
But progress was slow, and myths prevailed about protecting wood. Not until the late 1800's did the microscope and Pasteur's germ theory of infection lead to an understanding of wood rot, the most widespread infirmity.

During the last 100 years, researchers have built a large body of knowledge on wood deterioration, its causes, and remedies for its control. Much research remains to be done, but it is equally important to extend this information to those using wood in harsh environments—and the saltwater environment is the harshest one of all.

With Sea Grant support, slide tapes and bulletins have come from the School of Forestry to help meet this communication need. Condon and Graham's Preventing Decay in Wood Boats (see the "For further information" listing, page 8) adapts this knowledge for mariners.

The bulletin in your hand and Helsing's Recognizing and Controlling Marine Wood Borers (see "For further information") emphasize wood structures near and along the waterfront—that is, shops, homes, docks, piers, and bridges.

Wood structures can be designed to last for decades, even for a century or two. All too often, however, they rot prematurely. Rot is the final stage of a decay process in which plants called fungi feed on wood. In nature's efficient recycling process, rot fungi help change



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dead and weakened wood into soil and nutrients for the forest. New trees growing in soil combine these nutrients and water from the soil with carbon dioxide from the air, in the presence of sunlight, to renew our wood resources.

Unfortunately for waterfront property and boat owners, the process is not confined to the forest. Because of the continually high moisture in the waterfront and marine environment, rot can be especially troublesome in wooden structures on the land and in the sea.

Preventing and controlling rot essentially calls for removing or changing the conditions that support growth of rot fungi. The old saying, "An ounce of prevention is worth a pound of cure," is true for rot, too. This bulletin describes how rot occurs and suggests ways to prevent and stop it.



Figure 1.—These shelflike brackets (left) are fruiting bodies of a decay fungus within these boards. A whitish to yellowish mat of a fruiting body (right) indicates a decay fungus within this Douglas-fir.

What are rot fungi?

Rot fungi, unlike green plants, lack the ability to manufacture their own food. They, therefore, must feed on other plants, including wood. Frequently the only clues to the presence of rot fungi are *fruit bodies*, such as a shelflike *conk* or a whitish mat (figure 1). Fruit bodies produce millions of microscopic seedlike *spores*. These spores are picked up and distributed over a wide area by wind, currents, birds, insects, and animals.

Landing on moist wood, the spores grow into the wood, eventually forming an extensive system of microscopic strands (figure 2). These strands secrete chemicals that dissolve the components of wood, converting them into food for the rot fungi in the process.

It is important to remember that early infection is *invisible* to the unaided eye. Eventually the wood discolors, softens, and loses its structure and strength. Once you can *see* the damage, decay is already in the advanced stage called rot.

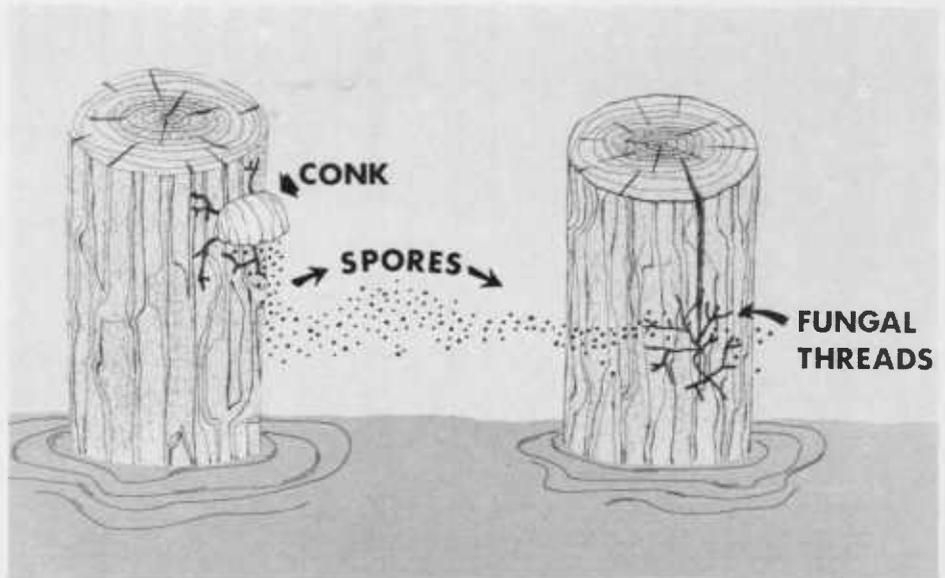


Figure 2.—Conks produce seedlike spores that spread and grow in wet wood, forming rootlike masses of fungal threads.

Brand names are used in this bulletin as examples only; their mention does not constitute an endorsement of the products named.

Rot fungi are broadly classified by the appearance of the deterioration they cause. Brown rotters leave a dark brownish residue. They lead to shrinkage that results in charlike fractures across the grain, and that cause chunks to break off easily.

White rotters, in contrast, leave a softened, lighter-colored wood without cross-grain cracks. Often, black lines may be present within white rot or at its margin.

In some instances, the residue may occur as pockets of white or brown rot scattered across otherwise sound wood.

Where to look for rot

Look for rot wherever untreated wood remains wet for long periods. A well-known example is untreated wood in contact with the soil. Look where:

- Water condenses on wood.
- Joining surfaces are exposed to wetting.
- Bolt and nail holes let in water.
- Seasoning checks trap water.
- Ends of pressure-treated piles, timbers, and lumber have been cut off and left unprotected.
- Beam ends are exposed to the weather, especially if a tight-fitting cover or flashing is applied over untreated wood.
- Wood is encased in fiberglass or other coatings that greatly retard drying. Such coatings rarely keep water out and become "incubation chambers" for decay fungi once water enters.

(Figure 3 illustrates these and other "where to look" situations.)

Deterioration that is not rot

Stain and mold fungi. Certain fungi penetrate wet sapwood in a radiating pattern of blue to black discoloration that *cannot be removed*; this is called *sap stain*. Other fungi cause mold or mildew that discolor the surface of wet wood (turning it blue, black, brown, green, red, or orange). They occur in speckled to blotchy patterns frequently

on painted siding that has no mildew protection and is shaded from the sun. You *can* remove mold discoloration by sanding. Mold and stain do not discolor heartwood, and they have little or no effect on wood strength; but they *do* indicate wet conditions suitable for the growth of decay fungi.

Iron stain. This is a familiar sight as dark streaks in wood around or below nail heads. The grey to black discolorations have no effect on strength. You *can remove* iron stain; wash the wood with oxalic acid, obtainable at most drugstores.

Wood-metal corrosion. Wood resembling pulp or rot in the vicinity of metal may be the result of electrical currents caused by the close contact of dissimilar metals. Impurities in iron can result in this reaction around a single iron fastener. This *wood electrolysis* is especially common in wood with attached metal in contact with saltwater, but it can also occur in freshwater and on land.

Leakage of electricity from boat motors can cause acid and alkaline (pH) changes in the hull of your boat. *Acids* bleach wood much like white rot fungi, and *alkaline solutions* color wood brown much like brown rots. Eventually, the wood is destroyed. (See *Cathodic Protection of Boats in Saltwater*, "For further information," page 8.)

Attack by wood-boring insects. Termites, carpenter ants, powderpost beetles, and buprestid beetles tunnel into and ultimately destroy wood. Often the insects or their grubs may be found in rotting wood. Termites use wood for both food and shelter; carpenter ants only nest in wood. Powderpost beetles make 1/2-inch (12.5-mm) oval holes as the adults emerge to start new colonies. Exit holes or tiny mounds of fine wood particles, fecal pellets, or shed wings signal the presence of insects.

Attack by marine borers. In saltwater, shipworms (related to clams) burrow internally, quickly riddling unprotected wood with holes. Working more slowly, gribbles (related to crabs) tunnel just below the surface. Shipworms often leave little evidence of their presence on

the wood surface, but gribbles cause a surface erosion and eventually an hourglass shape on unprotected wood.

Along the Pacific Northwest coast, fortunately, properly pressure-creosoted wood resists borer attack. In warmer southern waters, stronger measures may be necessary: the more expensive dual treatment (first a copper-arsenic formulation, then creosote) or heavy applications of the copper-arsenic alone. (See *Recognizing and Controlling Marine Wood Borers*, "For further information," page 8.)

How to detect rot

Detecting rot is not difficult if you know where to look and how to inspect wood. It is easy to confuse rotten wood with wood that is wet or discolored, so take time to learn the facts. (See *Wood Pole Maintenance Manual*, "For further information," page 8.)

To find internal rot, commercial inspectors sound poles and timbers with a hammer and then drill or core suspicious-sounding zones; they also inspect areas around large seasoning checks, joints, unprotected ends, and bolt holes—wherever water can collect.

What can you do to inspect for rot?

Sounding. Striking wood with a hammer is a simple, rapid method for locating internal rot. Hammering can break through thin shells of sound wood to the rot beneath, producing a dull thud in wet rotten wood or a hollow, drumlike sound in dry rotten wood—in contrast to the sharp ring of solid dry wood.

Drilling. When you drill with a brace and bit or power drill, a sudden reduction in resistance to the drill often indicates rot or a rot pocket. To inspect large timbers more easily, you can mount a twist drill of about 3/8 inch (1 cm) diameter on an extension of a slightly smaller diameter. Flood all inspection holes with a preservative and plug with preservative-treated dowels to prevent infection of sound wood.

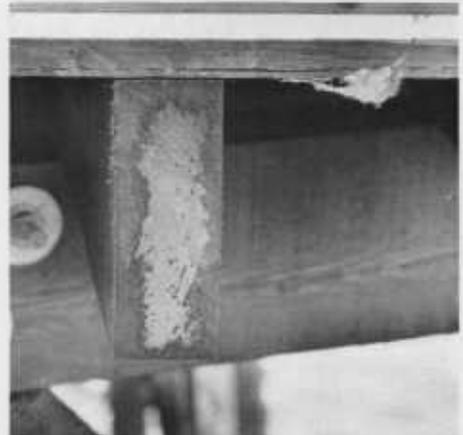
Examine the wood you remove for the fine particles that indicate rotten wood; these may have a moldy odor. *Caution:* Wet wood sometimes drills easily, like rot, but the wood particles are fibrous and tough.



Water condenses on a window frame . . . joined surfaces on this deck have absorbed moisture (the grass tells it all!). . . .

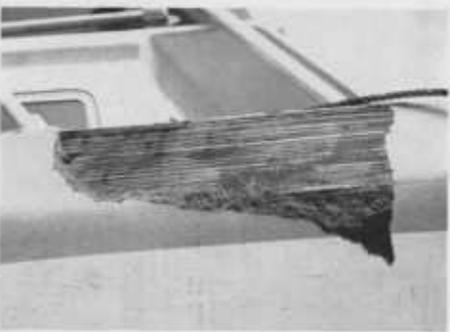


Seasoning checks trap water . . . bolt and nail holes absorb it, too. . . .



This beam end shows preservative penetration—but nothing will protect its interior from moisture . . . there was no protection, either, for the sawed-off ends of these piles. . . .

Figure 3.—Key situations in the marine environment where untreated wood can remain wet for long periods.



The plywood that covered this beam end retarded drying and became an incubation chamber for fungi, once moisture entered . . . fiberglass next to wood also retards drying. . . .



Decay problems can also arise in pressure-treated wood—decay within seasoning checks that open past the protective shell; decay resulting from inadequate treatment. For information on what to do about this, see the slide tape, Improving the Performance of Wood in Waterfront Structures (page 8).

Coring. An increment borer, such as foresters use for removing a slender cylinder of wood to determine growth rate of trees, permits internal examination for rot and depth of preservative treatment. A trained technician can test these wood cores for decay fungi that may be present but not visible. Flood and plug all such holes—so that your own testing process does not promote the infection of sound wood! (See figure 4.)

Splinter test for rot. Rotten wood usually is obvious, but sometimes a question can arise as to whether wood is in an early stage of decay. A traditional marine inspection test uses a pointed tool to pry up a small piece of wood. If a long, splintering break occurs, the wood probably is sound. If the wood breaks abruptly or is punky (soft), it is probably infected with a decay fungus (figure 5).

What conditions favor or prevent rot?

Rot fungi require certain conditions for their development and reproduction: air, water, a favorable range of temperature, and suitable wood for food. When you exclude or limit any one of these, you prevent or stop rot. The principle is just that simple; actually preventing rot, of course, is something else.

Air. You will rarely be able to control this factor unless wood is submerged in water or buried deep in the ground, where oxygen is excluded. Foundation pilings driven below the water table are a unique example of rot prevention by eliminating air. Pilings rotting above the water line *but not below* provide dramatic evidence of the role air plays in the decay process.

Water. Keeping wood dry is the most widely used means of protecting it from rot. Wood with a moisture content of 20% water or less (dry weight basis) is safe from rot fungi. Ground moisture, rainwater, plumbing leaks, or condensation (such as inside boat cabin windows) are the commonest sources of wetting leading to rot. Wood will rot outdoors or indoors, in the ground or above the ground, if it remains damp, but not so wet as to exclude air.

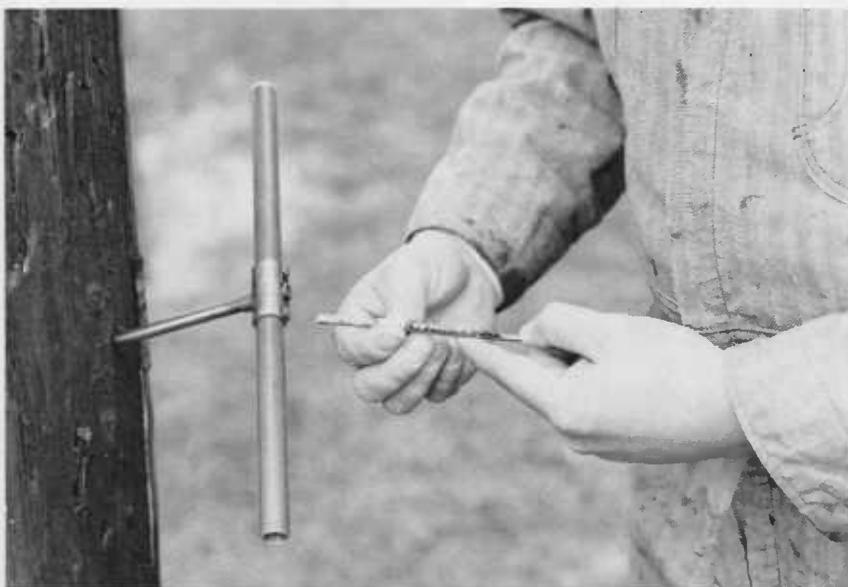


Figure 4.—A trained technician can test these wood cores for decay fungi that may be present—but not visible.

Bilges of boats, crawl spaces of homes, and gear sheds are especially vulnerable to rot from condensation caused by a combination of poor ventilation, humid air, and fluctuating temperatures. Condensed water on windows, pipes, nails, concrete, and wood is a sure sign of humid conditions.

Temperature. Most rot fungi grow best at temperatures between 70 and 90°F (21 and 32°C); a few need a somewhat lower range. Fungal growth slows and stops as the temperature decreases to 32°F (0°C), but freezing temperatures do not kill fungi. Fungal growth slows as the temperature exceeds 90°F (32°C), and all rot fungi are killed at wood temperatures of 150°F (65°C) or higher.

Suitable wood. Unprotected sapwood from all trees and heartwood from most trees are nondurable, rotting within 2 to 5 years when placed in moist ground. The heartwood of a few native trees (black locust, cedars, juniper, redwood, white oak, and yew) and some tropical trees (teak, ironbark, greenheart, and Honduras mahogany) can be quite durable, lasting many years in ground contact and longer above ground or water.

However, durability varies greatly, especially between old- and young-growth trees. The supply of durable heartwood is rapidly shrinking as the large trees disappear from our forests (younger trees contain a larger proportion of sapwood, and their heartwood has lower durability).

Sapwood and nondurable heartwood can be pressure-treated with preservatives to provide long service—30 to 50 years or more—even under the most severe service conditions. When you plan to use sapwood or heartwood of Douglas-fir, hemlock, spruce, pine, or yellow poplar in critical locations, or where replacement is difficult, have it pressure-treated first.

How to prevent and stop rot

Kept dry, wood has remained free of deterioration for thousands of years. The following are a few common causes of rot and ways to prevent it from occurring. In general, build to keep structures safely dry or protect wood exposed to water with an appropriate preservative.

Homes. (See figure 6.) Wood protected from rain under a properly



Figure 5.—The splinter test is useful for detecting decayed wood. Long splinters (above) indicate sound wood. Soft, easily broken wood around the probe (below) indicates decay.

maintained shelter requires minimal concern, but there are a few critical things to remember. Activities such as cooking and washing can evaporate 3 gallons of water into the air each day for a family of four. Ventilation and exhaust fans help to remove much of this water.

- **Water vapor** from inside the home passes through exterior walls that lack vapor barriers. If humidity within the home is high and if outdoor temperatures are cold enough, water vapor can condense and wet wood within the walls. When you are planning construction, install vapor barriers on the warm side of walls.
- **Keep untreated wood off the ground** by providing at least 8 inches (20 cm) of clearance from finish grade to mud sill and 6 inches (15 cm) to siding. In the crawl space, provide at least 18 inches (45 cm) between the ground and girders.
- **Covering the ground in crawl spaces** with 4- or 6-mil (1- or 1.5-mm) polyethylene reduces greatly the amount of water vapor in the air and the chance of rot in walls and floors.
- **Proper ventilation** keeps relative humidity low.

Closing crawl space vents to conserve energy during winter months can result in higher humidity, condensation, and rot above the concrete foundation walls. *Do not close these vents*; keep them unobstructed by vegetation. (Yes, this is a trade-off with the need to conserve energy, but consider what is at stake.) Be sure to keep attics well ventilated, especially after insulating.

Flashing, when properly installed, provides good drainage and prevents water seepage. Channel roof drainage away from buildings.

Wood structures exposed to the weather. Wood above ground or water—and exposed to weather—requires more protection than sheltered wood. Take appropriate steps to remove water rapidly. Space your decking and do not double-plank or cover deck with plywood, carpeting, or other materials that trap water. Blacktop or concrete has provided good protection, except where cracks open and drainage is ineffective. Rot is more difficult to detect in these cases. *See that all wood in saltwater or in ground contact is commercially treated to appropriate standards* (see section on “Pressure-treated wood”).

- *Protect cutoff pile tops* by applying a preservative to the exposed, untreated wood and covering with a cap of roofing cement, metal, or other waterproof material. Sloping pile tops *does not* drain water; it makes protecting tops more difficult.
- *Whenever you make cuts or holes* in treated wood, flood preservatives onto the freshly cut surface. Avoid making cuts in wood submerged in saltwater. Do not handle treated wood with sharp tools, such as tongs, that may puncture the protected shell.
- *Use narrow, treated timbers bolted together*, rather than large timbers that check and expose untreated wood. A saw kerf to the center of a timber or pole prior to pressure treatment controls checking and prevents internal decay. Incisions or small slits in wood provide deeper and more uniform penetration of preservatives. (See *Improving the Performance of Wood in Waterfront Structures*, “For further information,” page 8.)

Stopping rot. Repair of rot usually requires removing the wood, drying, applying preservatives, and eliminating the source of wetting. If you cannot prevent wetting, you may find it necessary to rebuild with pressure-treated wood.

Removing rot. Since the rot fungi are in the solid-appearing wood that surrounds rotting wood, it is difficult to say how much “solid” wood you should remove. If you have removed the source of moisture and if the wood dries out, the rot will stop, so you may not have to remove the rotten wood. However, if there is a possibility that the wood will not dry or that it may be wet again, remove the rot and adjacent “solid” wood. As a guide, remove solid wood that is wet and replace with pressure-treated wood. A moisture meter is a useful tool for detecting wood above a moisture content of 20% (see *Wood Pole Maintenance Manual*, “For further information,” page 8).

Caution: Replacement of all rotten wood may avoid questions and problems that could arise when you put your property up for sale.

Preservatives and their use

Onsite treating. Chemical preservatives poison the fungi that feed on wood. Flooding with a brush or spraying wood preservatives in the right places can do much to protect wood above ground, or above water, from rot. However, preservatives applied in this way do not penetrate wood readily, so do not depend on this method to *stop* rot. (What appears to be penetration is usually the solvent evaporating from the wood surface.)

Sapwood is most easily penetrated by preservatives; heartwood is usually difficult to treat.

- Pine sapwood is very permeable and treats well by soaking.
- Sapwood of many other trees is difficult to penetrate and requires longer soaking.
- Dry wood treats much more easily than green wood.
- Flooding or dipping provides only a surface treatment but can be very helpful for protecting ends, joints, and bolt holes, or wood above ground.

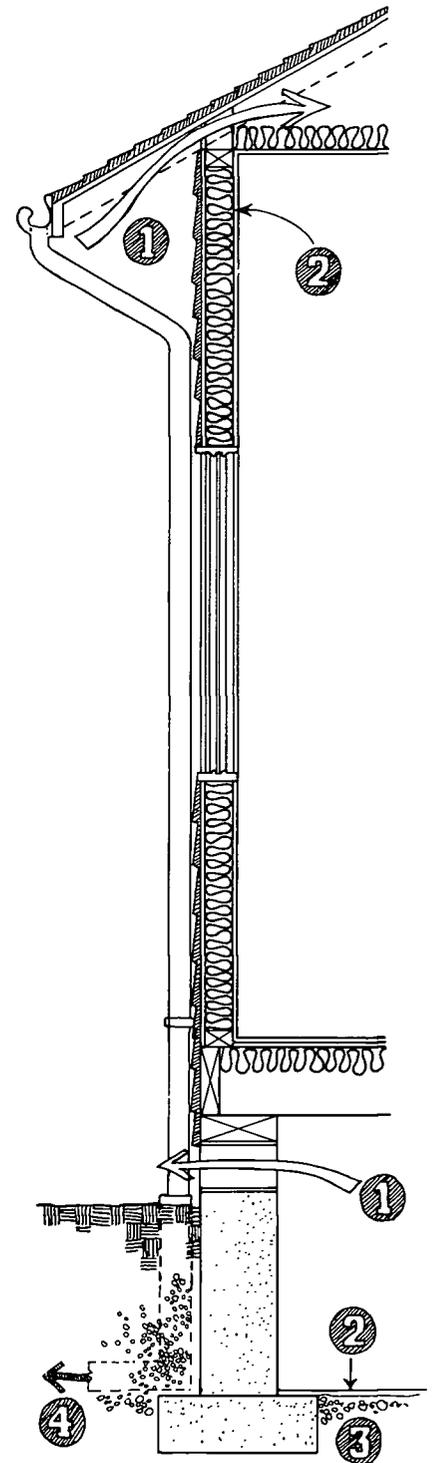


Figure 6.—A cutaway diagram of a house. (1) Good ventilation allows proper flow of air (white arrows). (2) Vapor barriers protect walls and crawl spaces. (3) Drainage below the house has been well planned. (4) Drain pipe carries rainwater (dark arrow) away from the house.

- Treat all cuts or holes made in pressure-treated wood.

Preservatives commonly applied to prevent rot by soaking, dipping, or brush-flooding include the following (some trade names are Cuprinol, Wood Life, Penta Plus, etc.):

- copper naphthenate
- copper-8-quinolinolate (for wooden containers in contact with foods)
- creosote
- pentachlorophenol
- tributyltin oxide
- zinc naphthenate

All but creosote are usually dissolved in solvents such as mineral spirits or heavier oils.

Precautions:

- Preservatives are toxic chemicals. *The U.S. Environmental Protection Agency is reviewing their use; this process may result in the removal of some preservatives from the marketplace.*
- Keep these chemicals out of the reach of children.
- Store preservatives in labeled containers.
- Apply preservatives only in well ventilated areas and *not in confined areas* such as crawl spaces or boat bilges.
- Avoid preservative contact with eyes or skin. Wash exposed skin after treating and before smoking or eating.
- When applying preservatives, especially over water, *guard against drip.*
- Follow the manufacturer's recommendations in every detail.

Pressure-treated wood. *This is a must* for saltwater immersion, ground contact, and damp conditions. Generally, this means that you must have the work done by a commercial treating plant, equipped with chambers in which preservatives can be applied to wood under high pressure and temperature. This process impregnates wood to a specified depth with a specified amount of preservative.

Whenever possible, cut wood members to final length and preframe all fastening holes and cuts *before* preservative treatment. Specify that the wood be treated to appropriate standards set by the American Wood-Preservers' Association.

For further information

Printed materials

- Condon, Edward J., and Robert D. Graham, *Preventing Decay in Wood Boats*, Oregon State University Extension Service, Sea Grant Marine Advisory Program Publication SG 23 (Corvallis, reprinted 1978).
- Graham, Robert D., and Guy G. Helsing, *Wood Pole Maintenance Manual: Inspection and Supplemental Treatment of Douglas-fir and Western Redcedar Poles*, Oregon State University, Forest Research Laboratory (Corvallis, 1979).
- Helsing, Guy G., *Recognizing and Controlling Marine Wood Borers*, Oregon State University Extension Service, Sea Grant Marine Advisory Program Publication SG 49 (Corvallis, 1979).
- Mallon, Michael H., and Edward Kolbe, *Cathodic Protection for Boats in Saltwater*, Oregon State University Extension Service, Sea Grant Marine Advisory Program Publication SG 46 (Corvallis, 1979).

This bulletin was prepared by Guy G. Helsing, research assistant, Forest Products Department, Oregon State University, and Robert D. Graham, professor of forest products, Oregon State University.

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Slide tapes

These sets are available from Forestry Media Center, c/o Business Office, **764-4702** School of Forestry, Oregon State University, Corvallis, OR 97331 (rental \$12 each, purchase \$70 each). Oregon residents may borrow sets (no rental fee) from Extension Marine Agent Paul Heikkila, Coos County Extension Office, 290 N. Central, Coquille, OR 97423.

Above-Water Inspection and Treatment of Wooden Waterfront Structures (75 slides, 18 min). Provides information about where and how to look for deterioration in waterfront structures and how to stop rot in large timbers and piles.

Improving the Performance of Wood in Waterfront Structures (77 slides, 15 min). Prescribes proper design and construction techniques to obtain good serviceability of wood in a harsh environment.

Wood Destroyers in the Marine Environment (75 slides, 15 min). Describes the organisms involved in marine wood deterioration, the nature of their attack on wood, and the conditions that favor their development.