COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

FOR - 54

WOOD-DESTROYING ORGANISMS & WOOD PRESERVATIVES

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Wood is a truly remarkable, naturally renewable resource. It continues to be the most popular building material because of its strength, beauty, versatility, and workability. Wood is ideal for commercial or industrial projects as well as for many do-it-yourself projects. However, wood that is used outdoors or in areas exposed to dampness needs to be protected against wood-destroying organisms.

Wood is a biological material. If used properly, it will not decay. If misused, lumber and other wood products succumb to the same biological processes that decompose dead trees in the forest. Wood may be rotted by fungi or eaten by insects. In the forest, decomposition of wood is nature's way of recyclying, but to the homeowner or farmer decayed wood products mean added repair or replacement costs.

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CAUSES OF WOOD DECAY

Fungi

Molds, some stains, and decay in wood are caused by low forms of plant life called fungi. Not all damaging fungi destroy wood. Some fungi stain wood without damaging its structure or decreasing its strength. These fungi penetrate and discolor the **sapwood** of softwoods and to a lesser extent, hardwoods.

Sapwood is the (usually) lighter-colored, younger (newer) wood produced in trees. The sapwood is composed of live cells that transport water and nutrients from the roots to the leaves and provide mechanical support for the tree.

In many species the sapwood can be contrasted to the **heartwood**, that is, the (usually) darker-colored central column of wood. Heartwood is formed as individual cells die and become impregnated with extractives, pitch, oil, and other extraneous materials.

Wood-staining fungi are not a problem if the stained lumber or wood member is painted or hidden in use, such as hidden supports for walls or ceilings. Wood-staining fungi can be a problem for quality grade woods used in furniture manufacturing and moldings.

Fungi have four basic requirements to grow and reproduce: moisture, oxygen, adequate temperature, and food. If you deny the organisms one of these four, then the wood does not decay. For example, wood pilings and posts completely submerged in water do not decay because oxygen is denied to the organisms. Sawmills once stored their sawlogs in ponds for this reason. Even today, most modern sawmills store logs, through the warmer part of the year, under a constant water spray. This retards the growth of fungi by reducing the oxygen content and temperature.

Water & Wood

Wood decay can also be controlled by lowering the moisture in wood to a point that the fungi cannot become established. Wood is **hygroscopic**. This means that dry wood readily takes up moisture when exposed to water vapor or liquid water. **Free water** is defined as liquid water that can be found in the cell lumens or cavities of wood. **Water vapor** is present in the air in the cell lumens. Wood also contains water that is bound to its cell walls **(bound water)**. As the name implies, bound water cannot easily be removed from the wood.

Wood can be protected from decay organisms by removing free water either by air drying or kiln drying. Air drying can take up to a year or longer. Kiln drying accelerates the drying process. All drying times depend on wood species and the size of the piece being dried.

When all the free water has been removed from the cell cavities, the wood is said to have reached its **fiber saturation point** (FSP). In strict terms, FSP is when cell walls are completely saturated with water and there is no liquid water in the cell cavities (although some water vapor will remain). For most species, this means drying the wood to a **moisture content** (MC) of 25% or less. Since moisture can very easily re-enter the wood, it must be kept dry to prevent future decay.

Wood is usually dried to a MC below the FSP for several reasons besides preventing decay: to increase wood strength, and to reduce uncontrolled dimensional change (shrinkage) during use. Most wood strength properties are constant with any MC above FSP, but they are negatively correlated with MC below FSP.

Wood seeks equilibrium MC with its surroundings. Since wood that is not dry will eventually dry to an equal MC with its surroundings, products and structures made with "wet" wood will shrink. The equilibrium MC of wood exposed to normal conditions outdoors, but under cover, is about 12 to 15% for much of the United States. Inside heated buildings the equilibrium MC is about 4 to 8%. Wood is commercially dried to a MC that approximates the MC where it will be used. Wood intended for interior use is dried at a mill and kept dry during and after installation.

Temperature

Temperatures above 120^0 F kill most fungi and temperatures below 35^0 F make fungi inactive.

Wood is often used in situations where it cannot be kept dry or at a constant high or low temperature sufficient to inhibit decay. Additionally, wood is not commonly used in an oxygen-free environment. However, as a food supply, wood can be denied to the organism by treating it with chemicals toxic to the wood-destroying organism. Wood is a source of food or habitat for bacteria, fungi, insects, and marine borers (the latter are not found in Kentucky).

KENTUCKY WOOD-DESTROYING PESTS

Wood that comes in contact with the soil creates ideal conditions for one of the most common wood-destroying pests in Kentucky, the subterranean termite. **Termites** live in colonies below ground and use wood for food. Dead wood in forested areas is commonly infested with this pest. Termite infestations can become established under concrete slabs, garage floors, patios, and porches in the home. In these situations, a barrier must be placed between the wood and the soil or the food source must be made unavailable to protect the wood.

Carpenter ants are another common Kentucky pest that can damage wood. These ants do not eat wood. Instead, they damage wood by removing the softer parts, creating hollow chambers that serve as nests. In the forest, live trees are occasionally infested. Infested trees are subject to serious injury and can be rendered worthless for lumber or pulpwood.

Carpenter ants eat common household foods and often invade homes from nearby nests. The ants may attack the wood in the home in any number of places, including supporting timbers, porch pillars, sills, girders, joists, studs, window casings, and external trim. Evidence of carpenter ant infestation includes the presence of large black ants, winged ants in the spring, piles of coarse sawdust borings, slitlike holes in woodwork, and a faint rustling sound in walls, floors, or other woodwork.

Both ants and termites can have wings. Ants differ from termites by having: (1) a pronounced constriction or waist between the thorax and abdomen, (2) bent or elbowed antennae, and (3) two pair of wings

of unequal size *(figure 1)*. Either of these pests can do severe damage to wood structures if left unchecked.

Kentucky has two forms of wood destroying beetles. Adult **powder post beetles** or Lyctus beetles are about 1/3 inch long and usually reddish-brown to nearly black. Wood injury from the powder post beetle is practically limited to air and kiln dried hardwoods and, less frequently, softwoods.

Typical damage can be identified by small "shot hole" size exit openings (1/16 to 1/12 inch) in wooden surfaces. In addition, a fine powder can be found in these holes, a result from feeding activity of grub-like larvae, and sometimes adult beetles. Joists, subflooring, hardwood flooring, sills, and interior trim are frequently attacked. Furniture and other wood products are also susceptible to powder-post beetle damage. Prevention is the key to managing powder-post beetle damage. Once an infestation has started, elimination of the beetles is difficult, expensive, and frequently uncertain.

The **old house borer**, a long-horned beetle, usually attacks pine sapwood. The adult is about 3/4 inch long, grayish-brown to black in color, and has two white patches on the wing covers. Old house borer larvae reduce sapwood to a powdery or sawdust-like consistency, often making a ticking or gnawing sound while working in the wood. Another sign of damage is an oval exit hole in the wood surface about 1/4 inch in diameter made by an emerging adult.

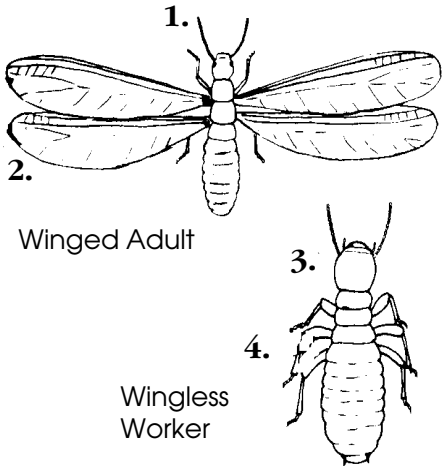
NATURAL WOOD PRESERVATIVES

Some tree species produce natural toxins in their heartwood that make them quite resistant to insects and decay. However, sapwood of all native U.S. tree species, and heartwood of most species, have a low natural resistance to decay *(Table 1)*.

Insects primarily attack sapwood and not heartwood because of the food found in special cells (parenchyma) of the sapwood. If the heartwood to sapwood ratio is high enough in the wood product, that product may be naturally resistant to decay. These woods may be suitable for moisture-contact uses. For example, osage orange *(Maclura pomifera)* posts are well known for their durability as fence posts. White oak *(Quercus alba)* heartwood has been used in the frames of the U.S. Navy's mine-sweeper ships. White oak and yellow poplar *(Liriodendron tulipifera)* have been found to be more resistant to termite attack than many other species.

In fast growing trees, even those that produce natural toxins, the ratio of heartwood to sapwood may be so low that even resistant tree species succumb to decay. Products made from younger trees may not contain enough heartwood to be decay resistant. REMEMBER: even resistant species are **not immune** to attack by decay fungi and insects.

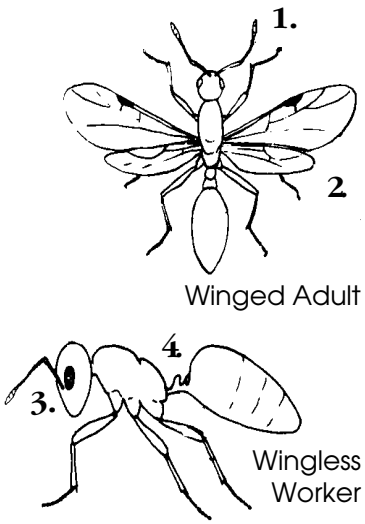
figure 1 - Four ways to tell termites from ants.



Termite

Compare these features:

TERMITE	ANT
1. Antennae Not Elbowed	1. Antennae Elbowed
2. Two Pair Wings of Equal Length	2. Two Pair Wings of Unequal Length
3. Eyes Absent	3. Eyes Present
4. Waist thick	4. Waist Thin



Ant

COMMERCIAL WOOD PRESERVATIVES

If heartwood of a very resistant species is unavailable for use, the food supply for less decay resistant species can be altered by treating the wood with chemicals. These chemicals are the wood preservatives used in commercial wood treating plants, and they are toxic to the wood-destroying organisms.

The most common wood preservative groups are creosote, oilborne preservatives (such as penta and copper naphthenate), and waterborne preservatives (such as chromated copper arsenate (CCA) and ammoniacal copper zinc arsenate (ACZA)).

Coal-tar creosote, a by-product of the pyrolysis of coal, is one of the most permanent and lasting wood preservatives. It is practically insoluble in water and therefore is the best preservative for water use. Railroad ties, utility poles, and marine pilings have been satisfactorily treated with coal-tar creosote. It is the only successful protection against some marine borers. Disadvantages of using creosote are its dark color, strong odor, oily and unpaintable surface, and the fact that it cannot be used indoors because of toxic fumes.

Oilborne preservatives enhance wood's dimensional stability because the oily solvents restrict the movement of water into the wood. Oilborne preservatives often leave an oily residue on the wood surface that makes it difficult to paint or stain. Some of the chemical substance may be transferred into the surrounding environment, such as skin or clothing, and oilborne preservatives cannot be used indoors because of toxic fumes.

Pentachlorophenol (penta) is a solid that is nearly colorless when mixed with light solvents for use on paintable surfaces not intended for ground contact. If the wood will come in contact with the ground, penta must be mixed with a heavier oil-based solvent carrier. Penta mixed with diesel oil is an excellent preservative for ground contact uses. Copper naphthenate is also used with an oil carrier. Generally, it does not offer the protection of either creosote or penta.

Waterborne preservatives are odor-free and clean to the touch. They generally discolor the wood but the surfaces are paintable and free of objectionable odors. Some

Table 1. A partial list of tree species and their heartwood decay resistance.

Species	Degree of Resistance
Black locust	*Very resistant*
Red mulberry	*Very resistant*
Osage orange	*Very resistant*
Cedar	*Resistant*
Juniper	*Resistant*
Cherry	*Resistant*
White oaks	*Resistant*
Redwood	*Resistant*
Honey locust	*Moderately resistant*
Bald cypress	*Moderately resistant*
Southern pine	*Moderately resistant*
White pine	*Moderately resistant*
Douglas fir	*Moderately resistant*
Alder	*Slightly to nonresistant*
Ash	*Slightly to nonresistant*
Basswood	*Slightly to nonresistant*
Beech	*Slightly to nonresistant*
Birch	*Slightly to nonresistant*
Cottonwood	*Slightly to nonresistant*
Elm	*Slightly to nonresistant*
Hackberry	*Slightly to nonresistant*
Hickory	*Slightly to nonresistant*
Magnolia	*Slightly to nonresistant*
Maple	*Slightly to nonresistant*
Red oaks	*Slightly to nonresistant*
Spruce	*Slightly to nonresistant*
Sweetgum	*Slightly to nonresistant*
Yellow poplar	*Slightly to nonresistant*

NOTE: Some species can be more resistant if found as old growth. For example, old growth bald cypress is very resistant because of the high percent of heartwood found in the resultant lumber. However, sound heartwood of any species is hard to find.

waterborne preservatives are less resistant to leaching than oilborne preservatives, but the chromated compounds chemically bind with wood sugars (fixation) to form virtually insoluble components. This "fixation" makes the preservative resistant to leaching. Principal compounds used in waterborne preservatives are copper, chromium, arsenic, and fluoride.

Softwoods or conifers are the most treated species. The market in CCA-treated southern pine accounts for almost half of the total southern pine lumber production. Wood treated with CCA preservatives constitutes about 80% of the treated-wood market in the United States.

BORATES AS WOOD PRESERVATIVES

The United States Department of Agriculture Forest Service and others are conducting research using borates as wood preservatives. **Borates** are compounds that contain the elements boron and oxygen. Borate-treated wood has been shown to be resistant from attacks by beetles, termites, and fungi. Borates are odorless, produce no vapor, and cause no color change in the wood. Research indicates that borates have low mammalian toxicity.

Another advantage of using borates is they penetrate unseasoned (undried) wood through the natural process of diffusion. In fact, moisture must be present for diffusion to occur. Diffusion allows borates to penetrate to areas most severe for fungal problems. This property negates the necessity of drying the wood before treatment, and allows borates to be applied to wood already in use, provided that the wood has an adequate moisture content.

A disadvantage of borates is that they are relatively unstable in wood. The borates can leach out if the wood is exposed to precipitation. Until more research is conducted, this negates borate-treated wood from being used for any application where the wood can get wet, or for any places where the wood comes into contact with the ground. However, borates may prove to be an economical and safe wood preservative for such uses as log homes, covered porches, or siding where the wood is protected from getting wet by an overhanging roof.

WOOD TREATING METHODS

Treatment with wood preservatives varies with species and the anatomy of the wood. The more decay resistant the wood, the harder it is to treat. Within a given species, sapwood treats better than heartwood. Because of the presence of tyloses (crystalline structures) in the cells of white oak, liquid cannot penetrate into the wood. This is why white oak is used in constructing cooperage barrels for the whiskey industry. However, the tyloses also impede the penetration of preservative chemicals into the wood. Unseasoned wood will not absorb sufficient amounts of preservatives (an exception is borates). **Seasoning** (drying) removes the free water and leaves room for the preservative.

Preservative effectiveness is influenced by:

- the type of preservative chemical
- the method of application
- the extent of penetration into the wood, and
- the retention of the preservative in the wood after treatment.

If any one of these is substandard, the wood will not treat properly and will be subject to decay.

The effectiveness of a wood preservative depends on the depth of its penetration into the wood. Inadequate chemical penetration can allow fungi or insects to enter through checks or cracks and reach unprotected wood. The depth of penetration depends on the wood species, the proportion of sapwood to heartwood, and the treatment process used. Wood preservatives can be applied by both pressure and non-pressure methods.

The best protection results from good penetration of the preservative substance into the wood. This is most easily accomplished using high pressure (100-200 lb/sq in.) to treat the wood. Large round cylinders are used to pressure treat most of the treated wood in today's market *(figure 2)*. Wood can also be soaked in preservative or have a preservative brushed on it. Neither of these methods results in good penetration or retention rates.

USING TREATED WOOD IN KENTUCKY

Kentucky ranks in the moderate zone for wood decay hazard *(figure 3)*. In general, all wood exposed to weather or in ground contact should be treated. Users should look for a **treated lumber quality mark** *(figure 4)*. This mark lists the quality agency overseeing the treatment, treating company, type of preservative, retention level, and other information. Generally, for the do-it-yourselfer, the most important information is the "proper exposure condition,"such as ***"above ground"*** or ***"ground contact."***

Vulnerability to Wood-Destroying Organisms

It it a common misconception that treated wood has been chemically treated throughout. Actually, it would be the exception to have a piece of treated wood with enough chemical in the center (except near the ends) to protect against wood-destroying organisms. Even pressure-treated wood does not generally have adequate penetration and retention of the chemical near the center of the piece for protection.

What Part of the Tree Produced this Product?

A treated product very popular with homeowners is CCA-impregnated landscape timbers. These are usually produced from a southern pine plywood peeler core. After the outside of the plywood log is peeled off to make veneer, the peeler core is left. Since this core represents the very center of the tree, the timber is made up almost exclusively of heartwood *(figure 5)*. Remember, heartwood of any species has poor preservative penetration rates. So the user should not expect the same protection as from wood products that contain more sapwood. Posts, poles, and square fence posts are larger in diameter than landscape timbers and generally have sufficient sapwood to be used in ground when pressure treated for that purpose.

Altering a Treated Wood Product

Whenever treated wood is altered by cutting or boring, the newly-exposed surface should be thoroughly sealed to keep water from entering the wood. Cutting or boring the wood exposes the heartwood that does not readily treat, or sapwood that has not been pen-

figure 2 - Wood is pressure treated in a large cylinder.

figure 3 - Three zones of decay hazard

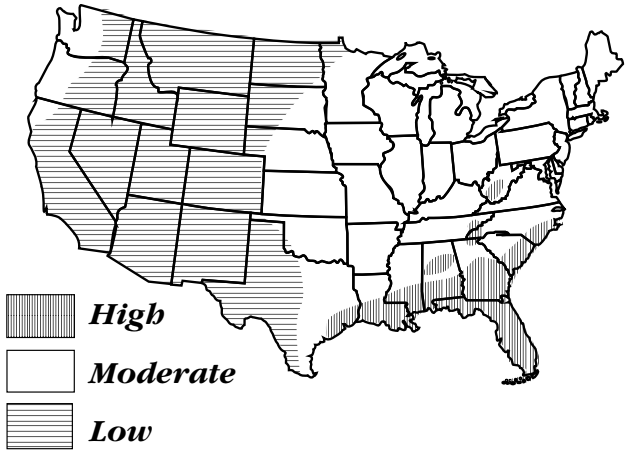


figure 4 - Example of a treated lumber quality mark

- ***a.*** - Year of treatment
- ***b.*** - American Wood Preservers Bureau trademark
- ***c.*** - Preservative used for treatment
- ***d.*** - Applicable American Wood Preservers Bureau quality standard
- ***e.*** - Trademark of agency supervising the treating plant
- ***f.*** - Proper exposure conditions
- ***g.*** - Treating company and plant location

etrated. If the exposed wood is allowed to take on moisture or is put in ground contact, the wood will decay.

Never put the newly-exposed end of a cut piece of treated wood into the ground. If a treated wood product must be cut, protect the cut end from getting wet and use the uncut end for ground contact. If the exposed surface cannot be kept dry, it should be painted thoroughly with copper naphthenate wood preservative or another of the commercial wood preservative brands that can be purchased over the counter. If at all possible, do not cut or bore into the untreated zone.

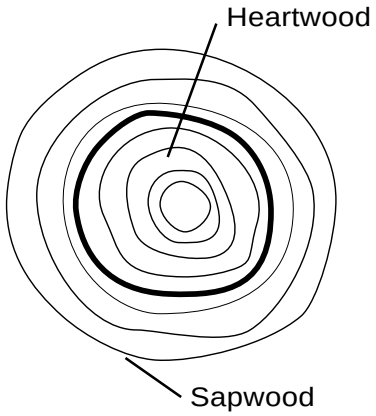
Proper Use of Treated Wood Products

The wood preservatives presently used in the United States are registered by the Federal Environmental Protection Agency (EPA) and are under constant review. Remember that wood preservatives are toxic materials and should be handled and used according to manufacturers' recommendations. **Wood preservatives fall into the category of "Restricted Use" pesticides. Only a licensed professional is permitted to purchase and use these chemicals**. (See your local county Extension agent for a copy of Cooperative Extension Service publication PAT 2, "Kentucky's Pesticide Applicator Training and Certification Program," for information about how you can become certified to use these pesticides).

Never burn treated wood. Toxic chemicals may be produced as part of the smoke and ashes. Dispose of treated wood by ordinary trash collection or by burying the wood.

In general, wood treated with penta and creosote should not be used where it will come into frequent contact with bare skin, and should not be used in interiors of residential buildings. Logs treated with penta should not be used for log homes. Penta and creosote treated wood should not be used in farm buildings where animals are likely to bite or lick the wood.

figure 5 - Cross-section of a log showing heartwood & sapwood zones.



Either penta or creosote can be used in farm buildings for building components that are in ground contact and where two coats of an appropriate sealer are applied to the treated parts of the wood. No treated wood should be used where the preservative may become a component of food or animal feed, for construction of beehives that may come into contact with the honey, for cutting boards or countertops, or for areas that may come into contact with public drinking water.

Prolonged inhalation of sawdust from treated as well as untreated wood should be avoided. Sawing should be performed outdoors while wearing a dust mask. Eye goggles should be worn when power-sawing or machining all wood. Before eating, drinking, or using tobacco products, areas of skin that have come in contact with treated wood should be washed thoroughly. Clothes accumulating preservatives and sawdust should be laundered before reuse and washed separately from other household clothing. (See your local county Extension agent for a copy of Cooperative Extension Service publication HE 2-319A, "Tips for Laundering Pesticide-Contaminated Clothing.") The building supply store or lumber yard will give you an EPA-approved Consumer Information Sheet concerning the correct handling procedures for your purchased treated wood product.

How Do I Know if the Wood is Treated?

Color of the treated wood product can give you a clue as to the preservative. Creosote-treated wood is usually black or dark brown; clear to dark brown may indicate penta-treated wood; and a greenish color may indicate a waterborne treatment such as CCA.

However, color alone will not tell you anything about penetration or retention rates. To ensure quality, always purchase wood products with a treated wood product quality mark. If the wood is to be used in ground contact, purchase only those wood products with the proper exposure condition for ground contact. Only pressure treated lumber should be used for ground contact purposes.

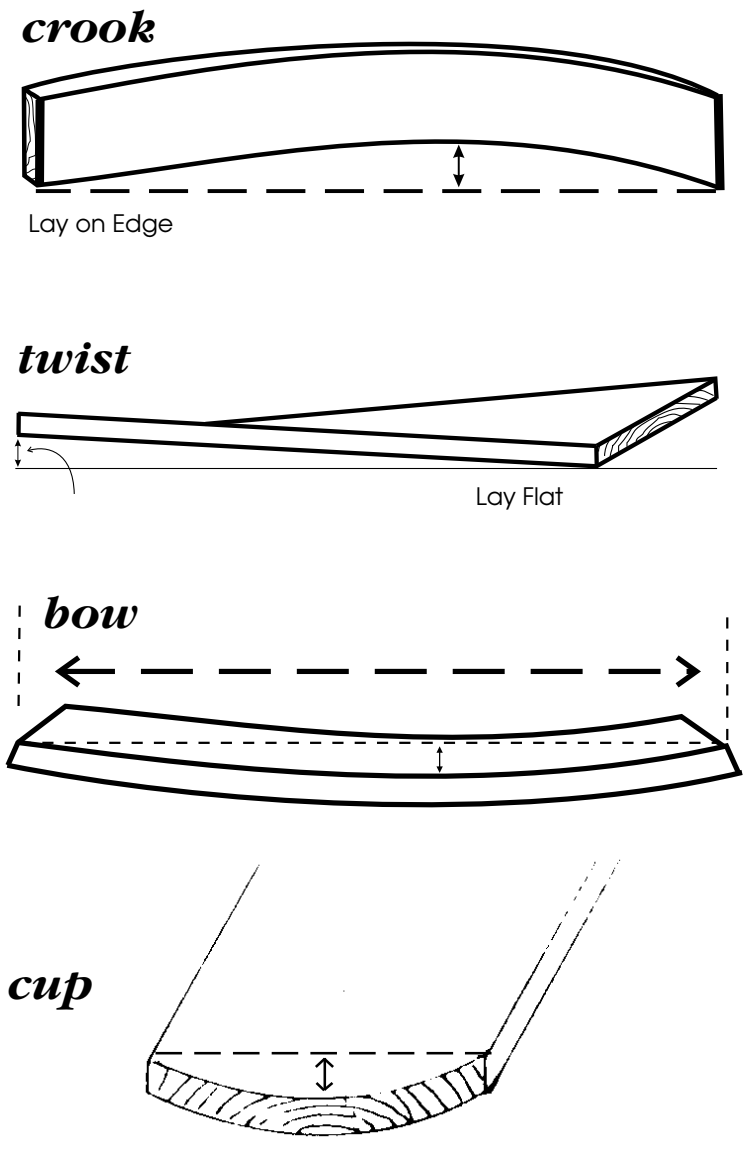
Additional Protection

You can do more to protect your treated wood. Even treated wood will shrink and swell with changes in environmental moisture. In effect, wood used outdoors for patios, decks, stairs, fences, etc. will gain moisture when humidity or precipitation is high and will lose moisture when humidity or precipitation is low. The treated wood is affected in several ways. As the wood changes in dimensional stability it can check

and split. If the penetration and retention of the preservative is not sufficient, insects or fungi can attack untreated wood by entering through these openings.

Wood can also warp as its moisture content changes. Cup, bow, crook, and twist can occur in treated and untreated wood *(figure 6)*. To minimize splits, checks, and warp, a good quality water-repellent can be applied to the treated wood. A water-repellent alone, however, will not protect the wood from insects or decay.

figure 6 -
Warp can occur in treated as well as untreated wood.



SUMMARY

Homeowners and farmers can use wood and keep it decay free by remembering:

■ water is wood's worst enemy, and

■ prevention and control of wood decay is accomplished by:
1. using dry, decay-free wood and keeping the wood dry
2. using heartwood of a durable species
3. using preservative-treated wood
4. not using untreated wood in construction within 18 inches of the ground, and
5. using only proper exposure condition "ground contact" pressure treated wood for ground contact purposes.

When purchasing treated wood products, always choose wood that is visibly clean and free of surface residue. If these steps are followed, structures made of treated wood products can virtually last a lifetime.

Mention of a product does not constitute a recommendation. Only those chemicals registered by the United States EPA should be used, and then only for uses as prescribed in the registration and in the manner and at the concentration prescribed. Information on registration status is available from the EPA, Washington, D.C.

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