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# Air-Drying Lumber

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Interest in air-drying lumber has increased in recent years. Now, many Oregon woods are dried in modest quantities by specialty shops, hobby woodworkers and manufacturers to produce lumber, furniture, bowls, and other novelty items.

Eastern Oregon has ideal conditions for air-drying lumber. Drying without a kiln in western Oregon presents more challenge, but can be done effectively.

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Extension Service, Oregon State University, Corvallis, Henry A. Wadsworth, director. This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U. S. Department of Agriculture, and Oregon counties. Extension invites participation in its programs and offers them equally to all people, without discrimination.

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# Air-Drying Lumber

Most woods must be dried before use to help prevent ruinous or unsightly cracking and discoloration. In the absence of commercially dried woods or a kiln with controlled temperature and humidity, wood can be stacked and air dried. The key to quality drying is to reduce the moisture content to a desired level, with a minimum of warping, cracking, and damage to the lumber.

Popular hardwoods such as Oregon white oak, Oregon ash, Oregon maple, Pacific madrone, Oregon myrtle (California laurel), red alder, tanoak, and chinkapin often are air-dried by the user. Juniper, Port Orford cedar, western redcedar, and Ponderosa pine are much-used softwoods.

Drying involves proper stacking to insure adequate air circulation, testing to determine moisture content, and in some cases treating to prevent decay and insect damage to the lumber. Wood must be dried to moisture contents that vary according to its intended ultimate use. Wood stored outdoors under cover will dry to a moisture content of about 12 to 14 percent in western Oregon and about 8 to 10 percent in eastern Oregon.

## Determining Moisture Content

Moisture content is the total amount of water in a piece of wood, expressed as a percentage of the oven dry (OD) weight of the wood. Moisture content (MC) is stated as:

$$\text{Percent moisture content} = \frac{\text{Weight of the water in wood}}{\text{OD weight of the wood}} \times 100$$

The moisture content of a piece of wood being dried can be easily determined by following these steps:

1. Cut a moisture content sample from 1 to 6 inches long and at least 18 inches from the end of the board, making sure that the sample will fit into an existing oven.
2. Weigh the sample to the nearest ounce. (Convert all weights to ounces.)
3. Place sample in an oven set at 220°F for 24 hours or until it stops losing weight.
4. Reweigh the sample (ounces). This is the oven dry (OD) weight.
5. The percent moisture content can be calculated as follows:

$$\text{Percent moisture content} = \frac{\text{Weight before drying—OD weight}}{\text{OD weight}} \times 100$$

Moisture content determinations should be made periodically while a load is drying to determine when the load has stopped losing water, and has reached equilibrium with the environment.

## Wood Shrinkage and Checking

Hardwoods and softwoods are made up of a number of different types of cells. Regardless of the type of cell found in these woods, there are certain characteristics which are common to all of them, namely, they each contain a cell wall and cell lumen (cavity). Figure 1 illustrates a single wood cell with its cell wall and cell lumen identified.

In a living tree, both the cell wall and cell lumen contain water, and the moisture content of the sapwood at this time is usually between 100 and 300 percent. Heartwood moisture content is 30 to 100 percent. Figure 2 illustrates the sapwood and heartwood regions of a wood cross-section. Water first leaves the lumen during the drying process, and then begins to leave the cell wall itself. The moisture content at which the cell lumen is completely free of water and the cell wall completely saturated, called the fiber saturation point, occurs at a moisture content of about 30 percent. Wood shrinks when water begins to leave the cell wall.

Due to the structure of the cell wall, wood shrinks differently in

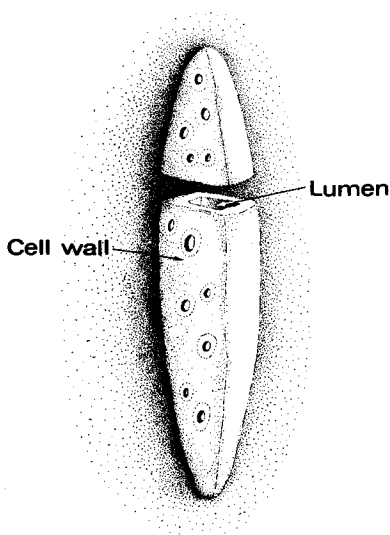


Figure 1. Locations where water may be found in the typical wood fiber.

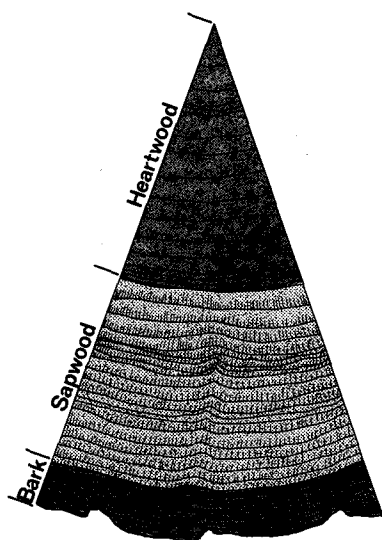


Figure 2. Greatest amount of water is found in the sapwood of a tree.

different directions. The least shrinkage occurs in the long axis (longitudinal direction) of the tree. The greatest shrinkage occurs parallel to the growth rings (tangential direction) of the tree. An intermediate amount of shrinkage occurs in a direction perpendicular to the growth rings (radial direction). Figure 3 illustrates these directions on a wood cross-section.

When wood is dried too rapidly, stresses develop in the wood. Often these stresses create checks or splits in the wood. Figure 4a illustrates where checks may occur in a log; Figure 4b shows checking in lumber.

Care must be taken when drying wood to keep the wood from drying too rapidly, especially thick turning stock, or checks will develop.

Checking will also occur in lumber where there are regions of cross grain. Cross grain is identified by zones in the wood where the grain direction deviates from the direction parallel to the long axis of the piece. Cross grain usually is found in areas surrounding knots or overgrown branches. Drying stresses occur at the cross grain-normal grain boundary because the cross grain region shrinks at a greater rate than the surrounding normal wood.

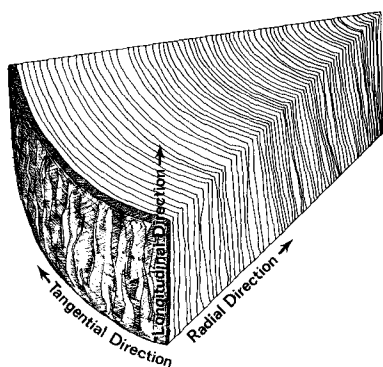


Figure 3. The greatest shrinkage of wood occurs in the tangential direction and least shrinkage in the longitudinal direction.

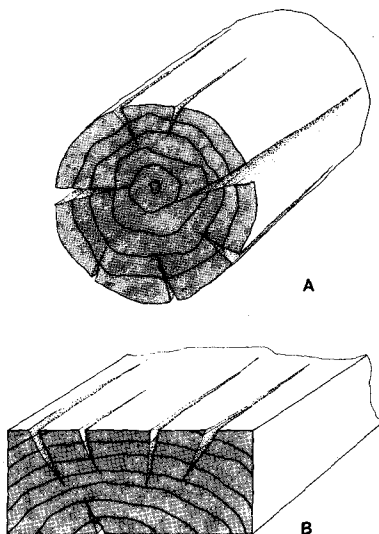


Figure 4. Unprotected ends of logs (A) and lumber (B) will check during drying. This results in a decrease in wood value.

## **Preparing Wood for Drying**

The wood to be dried should be reduced to the thinnest and narrowest shape from which the final product can be made. Be sure to allow for shrinkage (about 8 percent) and for surfacing and sanding. Roughing out a bowl or other irregularly shaped item, for example, will improve uniformity of drying. Rapid drying from the end grain surface of wood will cause checking or splitting. Rapid drying can be avoided by applying coatings such as roofing cements, wax emulsion, or an equal mix of linseed oil and shellac to the end-grain surface of the wood. These coatings should be available at hardware stores and retail lumber yards.

## **Factors Affecting Drying Rate**

Wood species and thickness as well as relative humidity, temperature, and air circulation all influence drying rate. As thickness of the wood increases, drying rate decreases. As a general rule, drying time is a function of the square of the wood thickness. In other words, if a one-inch-thick board takes one month to dry, a two-inch-thick board would take four months to dry, and a three-inch-thick board would take nine months to dry. In practice, however, drying time varies greatly.

Relative humidity is a measure of the amount of water vapor in the air. As the relative humidity of air increases, its water content increases and the drying rate decreases. During the winter months in western Oregon, the relative humidity is so high that drying occurs very slowly, if at all. Wood dries faster in eastern Oregon than in western Oregon because relative humidities usually are low in that region during most of the year.

As temperature increases above freezing, wood dries faster.

Air circulation is very important in determining drying rate and uniformity of moisture content. Good air circulation through a pile of lumber maintains a more uniform temperature and relative humidity by removing water vapor at the surface of the wood. Poor circulation raises the relative humidity of the air at the wood surfaces and slows drying even though the temperature and relative humidity of the air surrounding the pile of lumber favors rapid drying.

## **Piling of Lumber for Drying**

Proper piling of lumber provides good circulation of air and prevents distortion of lumber during drying (Figure 5). Lumber may be piled on a slope, or flat and covered with a sloping roof that extends beyond the end of the pieces. The foundation can be made of dry wood, concrete, or asphalt. If wood is used for the foundation it can



be pressure treated, soaked, or flooded with a preservative solution such as 5 percent pentachlorophenol mixed with 95 percent diesel oil or mineral spirits.

Layers of lumber of the same thickness should be separated by dry stickers approximately three-quarter inch by two inches in cross section. Stickers, equal in length to the width of the pile (Figure 5), should be placed in a vertical line (Figure 5a) spaced no more than two feet apart within each layer to prevent warping. Figure 5b is an end view of lumber stacked for drying. To repeat, each layer should consist of boards as nearly equal in thickness as possible. Lumber of different lengths should be separated into different groups of about equal length and piled with the longest boards on the bottom and the shortest boards on top. Align boards vertically from the bottom to the top of the pile. Separate piles by six to eight feet if more than one pile is to be used. An alternative to placing a sloping roof on the top of the pile, as illustrated in Figure 5, is to pile the wood in a roofed structure. Remember, good air circulation is the key to good drying.

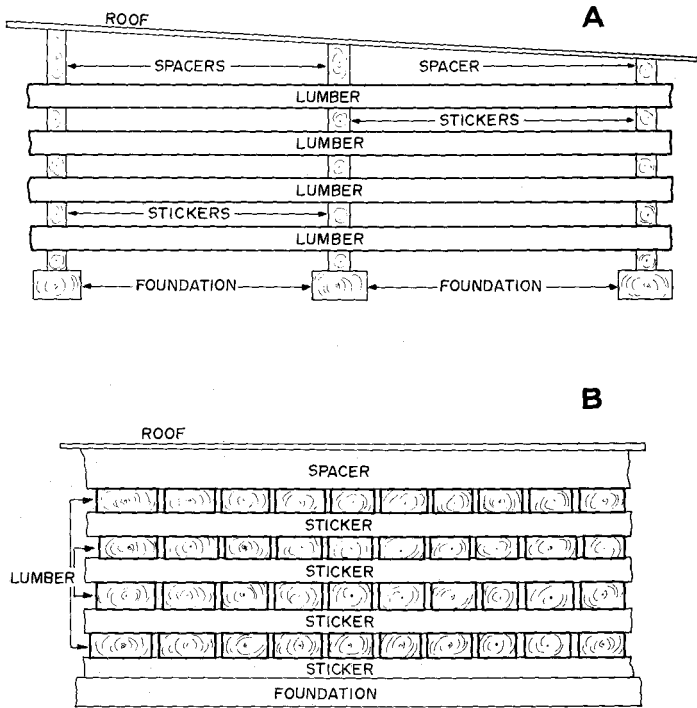


Figure 5. Placing stickers vertically aligned above the foundation members reduces lumber warpage. (A—side view, B—end view).

## Drying Wood to Desired Moisture Content

The time required to air dry wood to its equilibrium moisture content varies with locality. Wood will dry faster in spring and summer than in fall and winter. Lumber cut and piled outdoors by early spring should reach the following moisture contents by fall:

Western Oregon—12 to 14 percent

Eastern Oregon— 8 to 10 percent

Pieces of wood over two inches thick may take longer than thinner wood to dry. Pieces four inches thick or more may take as long as two years to dry to their equilibrium moisture content. Small pieces, of the type used by hobbyists, can be moved into a heated room during the winter months if care is taken in not allowing the wood to dry too rapidly.

The ultimate user of the wood should determine the final moisture content that best suits his needs. He may not require wood dried down to 8 to 10 percent moisture content. Wood at 15 percent moisture content may be sufficiently dried for his needs. Conversely, 8 to 10 percent moisture content may be too high. Below are listed the final moisture contents recommended for wood which is to be used for the selected items.

Indoor furniture, bowls, or carvings.....6 to 7 percent

Gun stocks .....12 percent

Fireplace mantels .....4 to 5 percent

Outdoor furniture or carvings

Western Oregon .....12 percent

Eastern Oregon .....8 to 10 percent

## Protecting Against Stain, Decay, and Insect Damage

There are three types of degrade that can occur during the drying process, especially with poor drying practices.

*Stain (the most common source of degrade).* Stains are dark discolorations usually blue, brown, or black, caused by plants called fungi and by reaction with chemicals, usually iron. Stains caused by fungi usually occur in sapwood, whereas chemical stains may occur in either heartwood or sapwood. It should be noted that myrtlewood is sometimes allowed to stain in order to obtain black decorative areas within the piece.

*Decay.* Decay is caused by plants that use wood as a source of food. The wood loses its luster, may discolor, and eventually decomposes. Badly decayed wood may be bleached or brown, usually is spongy when wet and has little strength. However, fine black lines around bleached areas give color to some novelty items. Decay usu-



ally occurs where pieces of wood are in contact when poor piling practices restrict air circulation.

*Insects.* Several insects attack hardwoods and softwoods before and during the drying process. Ambrosia beetles attack green (high moisture content) sapwood of both hardwoods and softwoods while it is still in the standing tree, or, more commonly, unpeeled logs that have been felled but not converted into lumber. Logs, therefore, should be converted into lumber or turning stock as soon as possible after the trees have been felled. If logs cannot be converted promptly, they should be raised off the ground and sprayed thoroughly with chemicals formulated to prevent ambrosia beetle attack.

The following is a partial list of Pacific Northwest suppliers of chemicals for preventing stains, decay, and insect attack. The chemicals may also be obtained from local industrial supply companies.

Chapman Chemical Company  
1238 N.W. Glisan  
Portland, OR 97209

Van Waters and Rogers, Inc.  
3950 N.W. Yeon Avenue  
Portland, OR 97210

Koppers Company, Inc.,  
Wood Treating Chemicals  
Department  
P.O. Box 23361  
Portland, OR 97223

Associated Chemists Inc.  
4401 S.E. Johnson Creek Blvd.  
Portland, OR 97206

In general, logs will be safe from abrosia beetle attack as long as the temperature remains consistently below 40°F.

The powder post beetle is the most important insect that attacks hardwoods. The importation of hardwoods and their increasing use is causing a rapid increase in damage throughout the United States. The small adult female beetle lays its eggs in the large pores (lumens) of the sapwood of hardwoods. The eggs hatch and the grubs tunnel into the wood where they feed on starchy material. The larvae may live in the wood for four years or longer before changing to adults that tunnel to the surface of the wood making holes about 0.10 inch in diameter. They may emerge over a period of years, sometimes through highly polished surfaces.

Insect attack can be prevented by brushing green sapwood with preservative before air drying, by including a preservative in solutions used to stabilize green wood, and by heating air-dried wood before use. As always, prevention is easier than cures.

Termites and carpenter ants may also be encountered, especially in salvaged wood. Salvaged wood is any wood that has been in the forest for a long period of time as logs or dead and dying trees. Ambrosia beetle attack and decay also may be present in such material. If salvaged wood is to be dried, it should be thoroughly inspected on the outside for advanced decay and insect holes.

Several chemicals are available for controlling decay and stain

as well as insects. Controlling those sources of degrade involves complex treatments. Some general comments on various treatments are made here however. For controlling stain and decay, sodium pentachlorophenate plus borax can be used. It should be mixed in a ratio of 1 gallon of liquid per 100 gallons of water or 10 to 12 pounds of dry powder per 100 gallons of water. This chemical is available in 55-gallon drums liquid form or 50-pound boxes dry powder. The compound should not be used on alder since it will discolor the wood. Benzene hexachloride can be used to control insect attack. It should be mixed in a ratio of 1 part benzene hexachloride to 28 parts water. This chemical is available in five-gallon quantities. Both chemicals can be sprayed or brushed on the lumber at the time it is obtained or at the time logs are cut into lumber.

### A Guide to Troubleshooting Air Drying Degrade Problems to Reduce the Occurrence of Checking, Warping, and Blue Stain

Checking	Warping	Blue stain and decay
<i>Note:</i> <i>A relatively slow initial drying rate is needed.</i>	<i>Note:</i> <i>Proper support and freedom from external forces are needed.</i>	<i>Note:</i> <i>Fast surface drying is needed or chemical treatment.</i>
1. Use wider piles or a double pile on a common foundation.	1. Place stickers in exact alignment over good foundation members.	1. Reduce width of pile.
2. Use minimum space between piles (2 feet).	2. Use close spacing between stickers, such as 16 inches.	2. Increase space between piles.
3. Pile boards edge to edge as nearly as possible in upper part of pile.	3. Use stickers of uniform thickness.	3. Provide 6 feet or more between rear end of piles.
4. Use minimum thickness of stickers (½ inch).	4. Avoid big variations in board thickness in any one layer.	4. Keep yard clean and avoid blocking air space below piles.
5. Use wider projecting stickers in front and rear of pile.	5. Use a roof that provides good protection from sun and rain.	5. Use a chemical dip (see Forest Products Laboratory Technical Note 225).
6. Use shields around pile to protect against wind, rain, and sun.	6. Provide some weight on top of pile to hold down top layers.	
7. In drying random length lumber, avoid unprotected and unsupported overhanging ends by sorting for length.	7. In drying random length lumber, avoid unprotected and unsupported overhanging ends by sorting for length.	
8. Use end coatings.		

Source: See Reference 10.

## Special Drying Techniques

Small, thick pieces of wood, especially those containing highly figured grain, burls, or decorative knot clusters, are difficult to dry without checking or splitting. Various techniques can be used to dry these pieces of wood.

A very effective method for reducing checking and splitting in thick pieces of wood is to treat the wood with polyethylene glycol (PEG), a special formulation made for this purpose. Novelty items should be roughly shaped while green before soaking with PEG. After soaking, shaping is completed and a special finish is applied. The reader should contact the Forest Products Laboratory, P.O. Box 5130, Madison, Wisconsin 53705, or the Forest Research Laboratory, Oregon State University, Corvallis, Oregon, for more details.

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