Drying Wood

The fundamental considerations

by R. Bruce Hoadley

It is ironic that our environment has us surrounded by trees—yet wood seems so inaccessible and expensive for the woodworker. Actually, abundant tree material is available to those who seek it out from such sources as storm damage cleanup, construction site clearance, firewood cuttings and even direct purchase from local loggers. With chain saws, wedges, band saws and a measure of ingenuity, chunks and flitches for carving or even lumber can be worked out. Also, it is usually possible to buy green lumber, either hardwood or softwood, at an attractive price from small local sawmills.

But what to do next? Many an eager woodworker has produced a supply of wood to the green board stage, but has been unable to dry it to usable moisture levels without serious "degrade" or even total loss. Certainly, the most consistent and efficient procedure would be to have the material kiln dried. Unfortunately, however, kilns may simply not be available. The cost of custom drying may be prohibitive, or the quantity of material too meager to justify kiln operation. But by understanding some of the basic principles of drying requirements and techniques, the woodworker can dry small quantities of wood quite successfully.

The so-called "seasoning" of wood is basically a water-removal process. Wood in the living tree has its cell walls water saturated and fully swollen with "bound" water and has additional "free" water in the cell cavities. The target in drying is to get the wood moisture content down to the equilibrium level of dryness consistent with the atmosphere in which the finished product will be used *(Fine Woodworking,* Fall 1976). In the Northeast, for example, a moisture content of about seven percent is appropriate for interior cabinetwork and furniture; in the more humid Southern states, it would be higher; in the arid Southwest, lower. Since removal of bound water is accompanied by shrinkage of the wood, the object is to have the wood do its shrinking *before,* rather than *after,* the woodworking.

Wood dries first at the outside surface, creating a moisture imbalance. This moisture gradient of wetter interior and drier surface zone is necessary to cause moisture in the interior to migrate to the surface for eventual evaporation. On the other hand, if a piece of wood is dried too quickly, causing a "steep" moisture gradient (i.e., extreme range between interior and surface moisture content), excessive surface shrinkage will precede internal shrinkage; the resulting stress may cause surface checking or internal defects (collapse or

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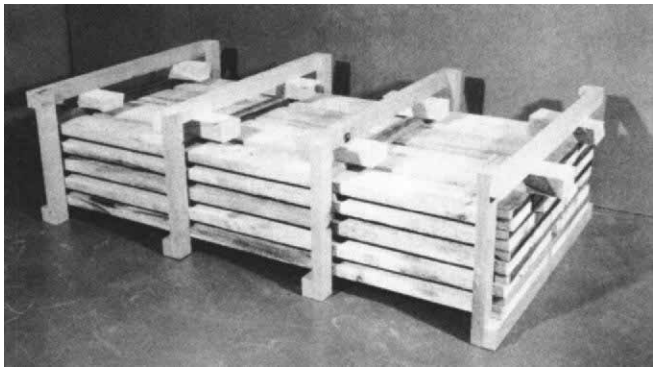
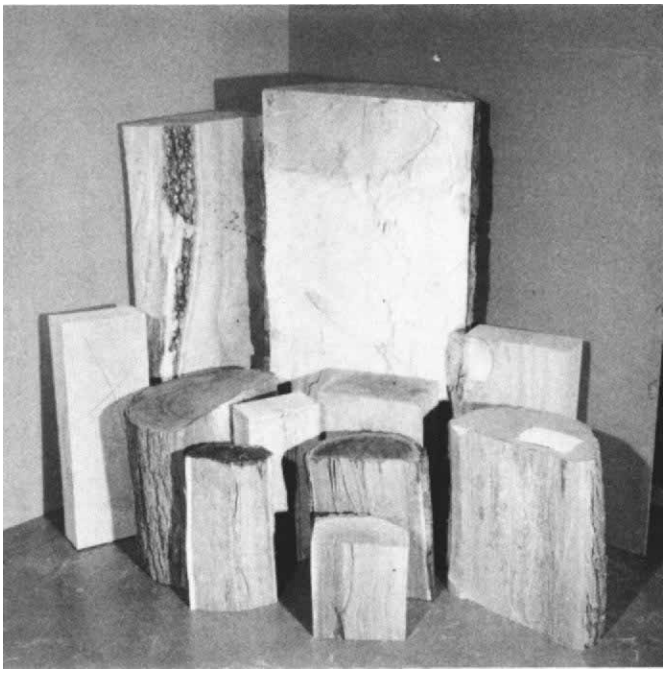




Small quantity of lumber piled for indoor drying is shown at left. Double wedges are tapped in tighter to maintain restraint as lumber shrinks. Above, an assortment of log sections and blocks for carving is arranged for indoor drying.

later honeycomb). Gradual drying with a moderate moisture gradient allows moisture from the interior to migrate outward, replacing moisture as it evaporates from the surface, thus maintaining gradual and more uniform shrinkage. Shrinkage in wood per se is a natural and normal part of drying which should be expected and accommodated; *uneven* shrinkage due to uncontrolled drying, however, is the culprit which we must deal with. On the other hand, drying cannot be too slow or unnecessarily delayed, lest fungi causing decay, stain, or mold have a chance to develop. In other words, the key to drying is manipulating conditions of humidity, temperature and air circulation to attain a compromise drying rate fast enough to prevent fungal development, but slow enough to prevent severe uneven shrinkage.

The practice of drying includes (1) proper cutting and preparation of the pieces, (2) appropriate stacking and location to allow regulated drying (and in lumber, restraint of warp), and (3) systematic monitoring of the drying progress. Let's review the application of these basic concepts to typical situations of drying small quantities of wood. We will consider the drying of short log segments or short thick stock, commonly used for wood carvings or stout turnings, as well as regular lumber or boards. We will also assume that fairly small quantities such as several log chunks or up to a few hundred board feet are involved—as occurs when one suddenly falls heir to a storm-damaged tree or purchases enough lumber for a single piece of furniture.

First let's look at proper preparation of the material. Selection of pieces should favor those with normal structure and straight grain. If possible, avoid pieces with large obvious defects. Lumber from trees with special grain will invariably twist upon drying. Irregularities such as crotch grain or burls are esthetically interesting but chancy to dry, since their cell structure usually has unpredictable shrinkage. Knots are troublesome if they are large enough to involve grain distortion. Logs with sweep or from leaning trees having an eccentric cross-sectional shape probably contain reaction wood and will almost surely develop warp and stress due to abnormal shrinkage.

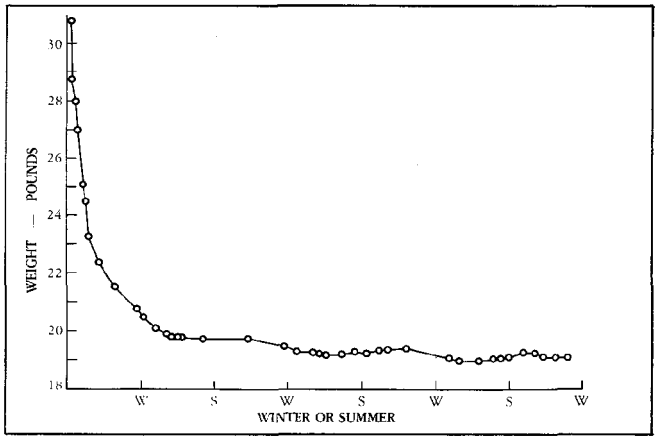
Whether preparing lumber or carving blocks, remember that normal shrinkage is about double tangentially as radially. My initial rule in splitting carving chunks from logs is to avoid pieces containing the pith. A half log or less which does not contain the pith can dry with a normal distortion of its cross-sectional shape (like slightly closing an oriental fan).

Another advantage of not boxing in the pith is being able to see if any overgrown knots are present which may not have been apparent from the bark side. Every knot-causing branch developed from the pith, so it is important to examine pieces from the pith side to discover hidden branch stubs, especially if they have decay. Additionally, the pith area is often abnormal juvenile wood that might best be eliminated.

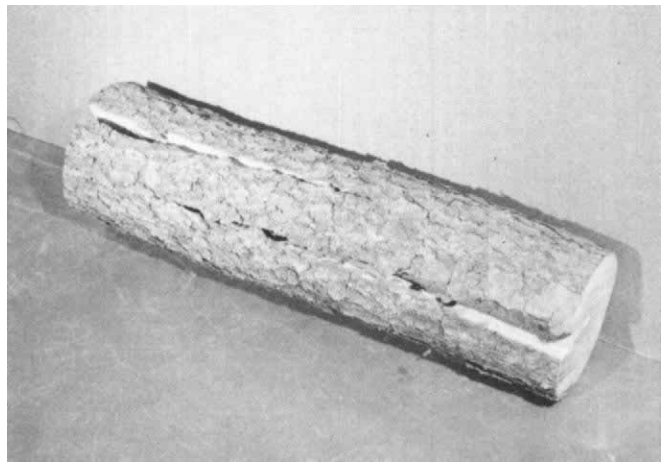
In sawing lumber, cup will be minimized by favoring quartersawed boards, which have no tendency to cup, or flatsawed boards taken furthest from the pith. Boards sawed through the center of the log, containing the pith or passing very close to it, will usually cup severely (or split open if restrained) along the center and might as well be ripped into two narrower boards before drying.

End drying is about 12 times as fast as drying through side-grain surfaces. Consequently, the regions near the ends of pieces drop below the fiber saturation point first. As the ends begin to shrink while the rest of the piece is still fully swollen, end checking usually results. In boards that are relatively long compared to their thickness, most moisture will leave slowly via the side surfaces; the influence of the end-checking problem is confined to a zone near each end of the board (about 6 inches from the ends of 1-in. boards). With relatively thick material, e.g., an 8 x 8-in. chunk 20 in. long, the end checking under uncontrolled drying can extend inward so far from each end that it riddles the entire piece.

To prevent the rapid end drying which will ruin carving chunks and the ends of lumber, the end-grain surface should be coated. Any relatively impervious material (such as paraffin, aluminum paint or urethane varnish) in ample thickness will do nicely. End coating can be applied to relatively wet surfaces by giving a primer coat of latex material first. It is important to end coat as soon as possible after sawing, before even the tiniest checks can begin to develop. Once a check develops, the cell structure failure will always be there even if it later appears to have closed. Also, when normal drying stress develops, a small check can provide the stress concentration point for further failures which otherwise might not have even begun in check-free wood. The purpose



Periodic weights of drying wood plotted on a graph show equilibrium moisture content has been reached.



As shown in this cherry log, the greater tangential than radial shrinkage is relieved by radial cracking.

of end coating is to force all moisture loss to take place from lateral surfaces.

In some species, radial drying may be significantly faster than tangential drying. Therefore, if the bark on larger carving blocks is tight (as with winter-cut wood), it may best be left on to slow the radial drying. If the bark has been removed from a heavy slab, it should be watched carefully during the early drying stages for signs of surface checking. Another reason for prompt end coating is to prevent ever present airborne fungal spores from inoculating the surface. If the bark is loose, it should be removed; otherwise the layer of separation will become a fungal culture chamber with undesirable results.

Don't forget to mark a number and date on each piece. It is amazing how easily your memory can fail once you have several batches of wood in process.

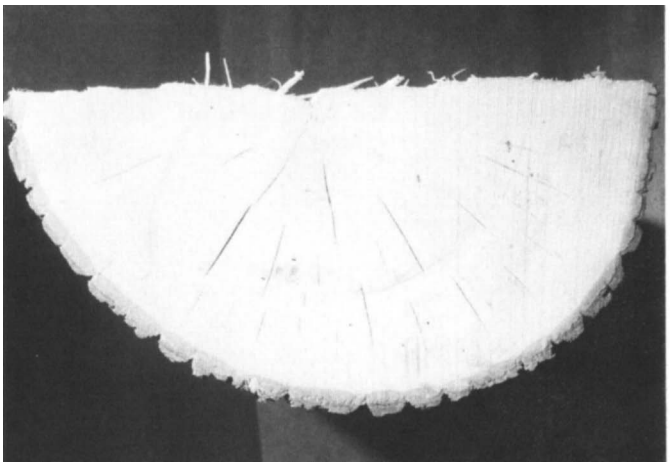
Next, consideration must be given to the correct piling and location of the material so proper drying will result. Piling must ensure maximum air circulation around virtually every surface of the material. Some means of elevating the bottom of the stacks should be provided and some sort of sticker strips are usually recommended to separate adjacent pieces. With irregular carving blocks, merely piling them loosely may suffice, as long as flat surfaces do not lie against one another. No attempt should be made to restrain distortion of large chunks. With lumber, however, carefully designed systematic piling is best.

The usual piling method is to arrange boards in regular layers or courses separated by narrow strips or stickers. This permits the free movement of air around the lumber, uniformity of exposure of the surfaces, and restraint to minimize warp. The stickers should be dry and free of fungi and at least as long as the intended width of the pile. In planning the pile, stickers should be placed at the very ends of each course and at least every 18 inches along the length of the boards, since loose ends hanging out of the pile lack restraint and dry too rapidly (resulting in excessive warp). It is best to have lumber uniform in length, but if random lengths are unavoidable, they should be arranged in a pile as long as the longest boards; within each course, stagger the position of alternate boards so their alternate ends are lined up with the end of the pile. This "boxed pile" system prevents excessive drying of overhanging ends. To prevent excessive drying degrade to the top and bottom courses or layers, extra outer courses of low-grade lumber or even plywood might be added to the pile. Stickers should be lined up in straight vertical rows. To ensure uniform restraint in a course, lumber and stickers should be as uniform in thickness as possible.

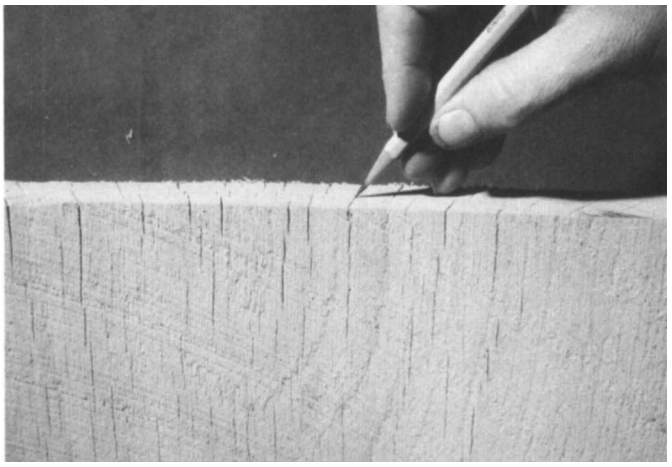
In large piles, the majority of the boards are restrained by the weight of others above. In small piles, extra weight (old lumber, bricks, cinder blocks, etc.) should be placed atop the pile. An alternate method of applying restraint is to assemble rectangular frames to surround the pile. The pile can be wedged against the frames and the wedges tapped further in to maintain restraint as the pile shrinks. Obviously the weighting or wedging should not be so extreme as to prevent shrinkage of the boards across their width.

In a commercial dry kiln, the operator can manipulate air circulation, temperature and humidity to dry the lumber gradually. He begins with a moderately low temperature and high relative humidity until the lumber (based on monitored samples) drops to a certain moisture content, say, near the fiber saturation point. He then establishes a slightly higher temperature and drier condition which he holds until the next lower prescribed moisture content is reached. Then he again establishes another warmer, drier level and so on until the lumber is dried. The so-called "kiln schedule" is a sequence of successively drier conditions which are regulated according to the moisture content of the lumber.

In home drying of wood, we must therefore try to choose locations or regulate conditions to allow only moderate drying at first, followed by more drastic conditions once the lumber has reached a lower moisture level. One logical starting place is out-of-doors. Except for especially arid regions, the relative humidity is usually moderately high. For example, in the New England area the humidity averages around 75 to 80 percent, which would give an equilibrium moisture content of 12 to 14 percent. Piles of blocks or stacks of lumber should be kept well up off the ground to avoid dampness, and should be protected from direct rainfall and sun rays as well. Any unheated building which has good ventilation, such as a shed lacking doors and windows, is ideal. Most garages serve well and even unheated basements are suitable if plenty of air space around the pile is provided. In air drying out-of-doors, some rather obvious seasonal variations will be encountered. In many Eastern areas, slightly lower humidity and more prevalent winds favor drying in spring months. In winter, if temperatures drop to near or below freezing, drying may be



End grain surface of a basswood half log which was not end coated in time shows a large numberofend checks.



Cross-cutting has revealed that the surface checks have penetrated deep into this white oak board.

brought to a standstill. You must therefore interpret conditions for each particular area. If wood is intended for finished items that will be used indoors, outdoor air drying will not attain a low enough equilibrium moisture content. The material must be moved indoors to a heated location before it is worked.

Surface checking should be closely watched. Minor shallow surface checking that will later dress out can be ignored. However, deeper checks should be considered unacceptable. The worst type are those which open up but later reclose. Often they go unnoticed during subsequent machining operations only to reveal themselves when staining and finishing of a completed piece is attempted. If any serious end checks develop, don't pretend they don't exist, or will ever get better or go away. For example, if a large carving block develops a serious check, this indicates fairly intensive stress; it is probably best to split the piece in half along the check, thus helping to relieve the stresses, and be satisfied with smaller pieces.

If wood must be located indoors from the very start, drying may be too rapid. Any signs of surface checks in the material suggest that some retardation may be necessary. This can be accomplished by covering the entire pile with a polyethylene film. Moisture from the lumber will soon elevate the humidity and retard the drying. However, this arrangement must be closely watched, since air circulation will likewise be stopped. Moisture condensation on the inside of the plastic covering or any mold on the wood surfaces may mean the pile has been turned into a fungi culture chamber and signals the need for speeding up the drying again. Common sense and intuition will suggest how often to check the wood and how to modify the storage location to speed up or slow down the drying. The seasonal humidity fluctuation commonly encountered in heated buildings must also be allowed for in determining the equilibrium moisture level.

Drying progress can be monitored by weight. Weights should be taken often enough to be able to plot a fairly coherent graphical record of weight against time. Weighing should be accurate to within one or two percent of the total weight of the piece. A large chunk in the 100-pound range can be weighed on a bathroom scale. Pieces in the 10 to 25-pound category can be weighed with a food or infant scale. Small stacks of boards can be monitored by simply weighing the entire pile if this is convenient. In larger piles, sample boards can be pulled and weighed periodically. Electrical moisture meters are perhaps the simplest means of keeping track of the drying progress in boards.

The last stage of drying should be done in an environment similar to the one in which the finished item will be used. The weight of the pieces will eventually level out and reach a near constant equilibrium with only faint gains and losses of weight in response to seasonal humidity fluctuations.

When material comes into equilibrium weight with the desired environment, it's ready. Don't pay attention to overly generalized rules like "one year of drying for every inch of thickness." Such rules have no way of accounting for the tremendous variation in species' characteristics or in atmospheric conditions. Basswood or pine decoy blanks four inches thick dry easily in less than a year, whereas a four-inch thick slab of rosewood may take much longer to dry without defects. In general, the lower density woods are easier to dry than higher density woods. Since the average cell wall thickness is less, moisture movement is greater and this results in faster drying. In addition, the weaker cell structure is better able to deform in response to drying stresses, rather than resisting and checking. After some experience is gained for a particular species and thickness dried in a certain location, a fairly reliable estimate can be made as to the necessary drying time. Here, the initial date you marked on the piece will serve you well.

Whether drying log sections or boards, remember that the drying must be somewhat regulated; usually at the beginning, indoor drying proceeds too quickly and needs slowing down.

In drying your own lumber or carving wood, one common problem is hesitation. You can't wait! If you do, fungi or checks will get ahead of you. Try to think out all the details *before* you get your wood supply; don't wait until you get it home to decide how you are going to end coat or where you are going to stack it.

But perhaps the greatest pitfall is greed. Most woodworkers never feel they have enough material put aside and tend to overstock if the opportunity presents itself. With green wood, this can be disastrous. Don't try to handle too much. Don't even start if you can't follow through. More material is ruined by neglect than by lack of know-how.

Finally, in drying wood, nobody has ever proved that it doesn't pay to cross your fingers.