a closer look

Understanding wood movement

LEARN HOW TO PREDICT DIMENSIONAL CHANGES IN YOUR FURNITURE PARTS

BY GERALD CURRY

One of the reasons I started working with wood was because it seemed like a seat-of-the-pants activity. Just a few tools, a pile of lumber, and me, limited only by my imagination.

Then I found out about seasonal wood movement, and things got a lot more complicated. My first step was to learn construction methods that accommodate that shrinkage and swelling, so my furniture wouldn't crack and its joints fail. But sound engineering isn't enough. I also needed to know more about the differences among various woods—and the science behind my materials.

Many of the important properties of wood—strength, hardness, texture, and color—can be judged simply by examining and using the material. Stability, on the other hand, is more elusive and extremely variable. Seat-of-the-pants guesswork just won't do.

Most of the shrinking and warping happens during the initial drying process, before we get the wood. Then we mill it flat and straight again. But the movement is far from over. The moisture content of wood will always try to reach equilibrium with the humidity of the surrounding air. As the humidity changes, so do the dimensions of the piece of wood, sometimes to an alarming degree. This constant movement causes the most problems for furniture makers: tops and doors that warp, drawers that jam in the summer, and so on.

Start with the right wood

A successful project starts with choosing the right materials. Wood selection, both in terms of species choice and grain orientation, is very important, even more so in regions like New England, where I live, which sees large swings in humidity. The chart on p. 84 will help you make smart choices.

The next thing you need to know is that almost all shrinking and expansion happens across the grain; changes in the length of a board are negligible and can be ignored. Wood shrinks and expands most in line with its rings, which is called tangential movement, but less at right angles to those rings, called radial movement. That's why flatsawn boards of most species will shrink and swell about twice as much as quartersawn boards of the same wood. Flatsawn is also much more likely to cup.

So it makes sense to use quartersawn, or something approaching it, like riftsawn, for your furniture parts whenever shrinking, swelling, and cupping would be a problem. Drawer and door parts are a good example (see "Engineering a Chest of Drawers," p. 30).

Why you need to calculate movement

Even if you build your projects to accommodate wood movement and choose the best materials for each part, there will be times when you need to estimate future movement very closely. One of the most critical examples is estimating the gap you need at the top of a drawer. I'll cover that on p. 86.

Armed with a few pieces of critical information, you can estimate how much any given workpiece will expand and contract. You'll need to know the shrinkage rates for the wood, the growth-ring orientation in the board (which tells you the shrinkage rate to use), the current moisture content (MC), and its future minimum and maximum moisture levels, based on the typical humidity levels where your furniture will live. After that, you have some math to do, but I'll make that as simple as possible, with the help of a few handy charts.

Gerald Curry has been making furniture in Union, Maine, for four decades.

Photos: Asa Christiana

Keys to predicting dimensional changes

If you live in the continental United States and stick to the common furniture woods, you can use the chart of shrinkage rates (below) and the maps on the opposite page to estimate the current moisture content (MC) of a board in your shop, and also to predict how much that board will shrink and expand. A moisture meter adds some precision to the process.

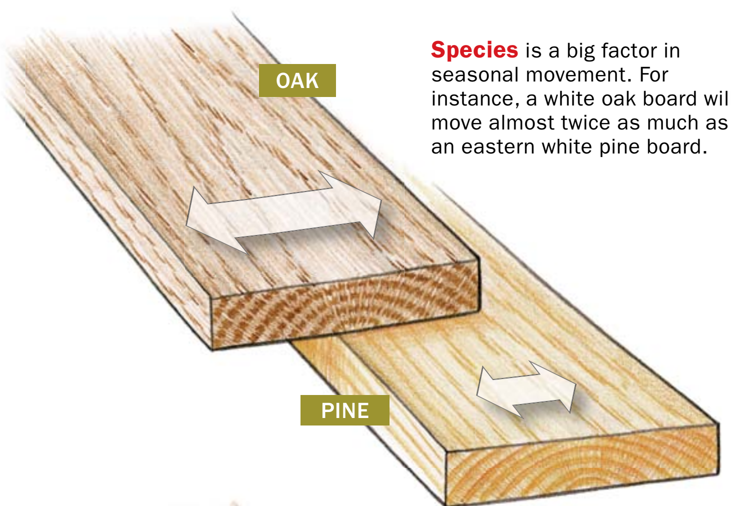
1. FIND THE SHRINKAGE RATE

The shrinkage rate describes how much a piece of wood shrinks as it dries from its fiber-saturation point (near 30% MC) to oven-dry, or 0% MC. Wood that shrinks at a certain rate will swell at the same rate. These shrinkage rates allow us to calculate dimensional change as the moisture content changes. I put the rates for the most common North American furniture woods in a chart, below right. If the chart doesn't list the species you're using, you will probably find it on the Forest Products Lab's website (www.fpl.fs.fed.us/research/centers/woodanatomy/index.php), where more than 400 tropical and 100 North American species are listed with extensive information on each.

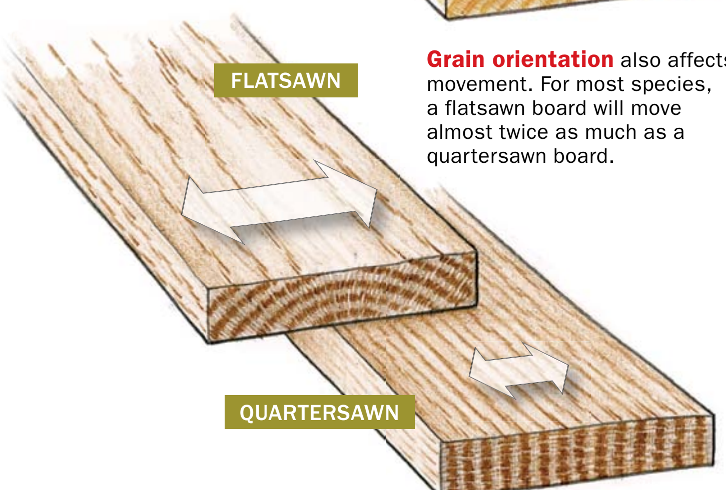
To know which shrinkage rate to expect, you need to know the grain orientation. That's as simple as looking at the end grain of the board. Flatsawn wood has growth rings that are parallel or nearly parallel to the face of the board, so they experience tangential movement; quartersawn wood has rings that are perpendicular to the face of the board, so movement occurs radially. The rings are seldom exactly vertical or horizontal, and the angle usually changes across the board, so you often will need to make a judgment call. In some cases, parts of a board will be tangential and other parts radial, and in that case you can calculate the dimensional changes separately and add them together. If the rings are 45° or more to the face, I consider it radial for shrinkage purposes.

Bear in mind that these percentages are the average rates for the species. Very precise predictions are not possible for any single piece of wood. So this is about estimating as accurately as you can, and then staying on the safe side.

BOTH SPECIES AND GRAIN ORIENTATION MATTER



Species is a big factor in seasonal movement. For instance, a white oak board will move almost twice as much as an eastern white pine board.



Grain orientation also affects movement. For most species, a flatsawn board will move almost twice as much as a quartersawn board.

SHRINKAGE RATES FOR COMMON NORTH AMERICAN WOODS

SPECIES	QUARTERSAWN	FLATSAWN
Alder, red	4.4%	7.3%
Ash, white	4.9%	7.8%
Basswood	6.6%	9.3%
Beech, American	5.5%	11.9%
Birch, yellow	7.3%	9.5%
Butternut	3.4%	6.4%
Cedar, eastern red	3.1%	4.7%
Cherry, black	3.7%	7.1%
Douglas fir	4.8%	7.6%
Elm, American	4.2%	9.5%
Honey locust	4.2%	6.6%
Madrone, Pacific	5.6%	12.4%
Maple, red (soft)	4.0%	8.2%
Maple, sugar (hard)	4.8%	9.9%
Oak, northern red	4.0%	8.6%
Oak, white	5.6%	10.5%
Pecan	4.9%	8.9%
Pine, eastern white	2.1%	6.1%
Pine, western white	4.1%	7.4%
Sassafras	4.0%	6.2%
Sycamore, American	5.0%	8.4%
Walnut, black	5.5%	7.8%
Yellow poplar	4.6%	8.2%

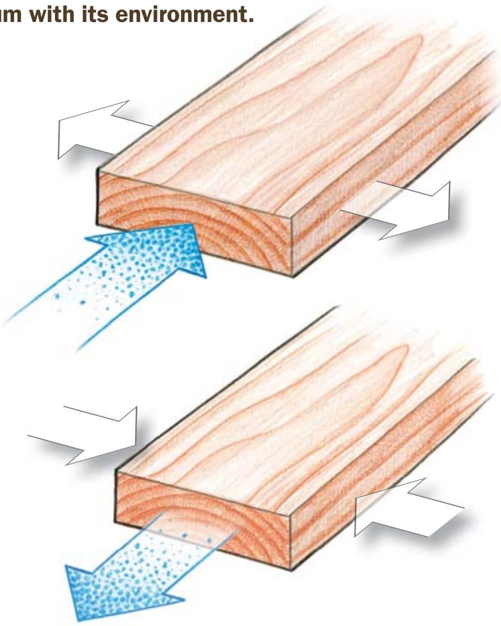
These rates assume perfectly vertical (radial) or horizontal (tangential) growth rings; reality is usually somewhere between. Look for low shrinkage numbers to find stable furniture woods.

Drawings: John Tetreault

2. DETERMINE THE CURRENT MOISTURE CONTENT

Far and away the most accurate and convenient way to obtain the current MC of lumber in your shop is with a moisture meter. I've found the type with pins to be much more accurate than the pinless variety. And at $200 to $300, a good meter is a smart investment for the serious woodworker.

Lacking a moisture meter, you can make an educated guess at MC by using the maps at right. This method works best toward the end of summer or winter when the interior of your boards will reach the equilibrium moisture content (EMC) depicted on the maps. Bear in mind that this won't happen unless the wood has been on stickers in your shop with decent air flow for some time, so it is in equilibrium with its environment.



Moisture in, moisture out. *Wood is a hygroscopic material, absorbing and releasing moisture throughout the year as humidity levels change. Wood cells expand and shrink in the process, affecting the width and thickness of a board. Finish will slow this exchange, but will never stop it.*

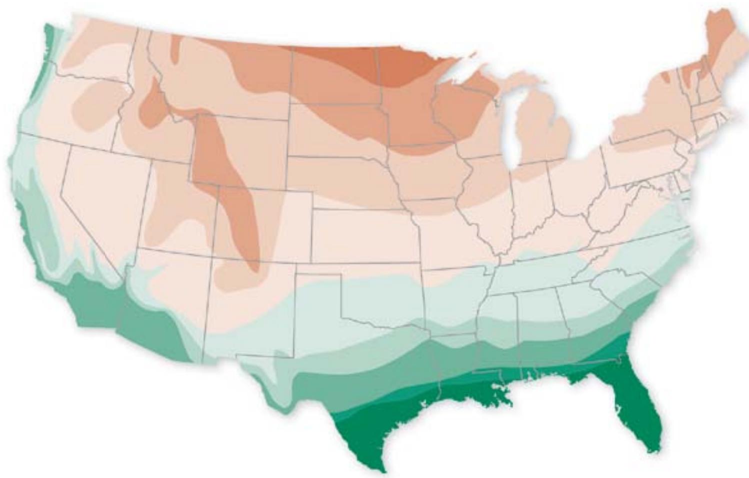
YOU NEED A MOISTURE METER

Instead of using charts to make a guess at the EMC in your shop or home for the season you are in, you can press a button on a pin-type moisture meter and get an accurate measurement of the boards you are using.

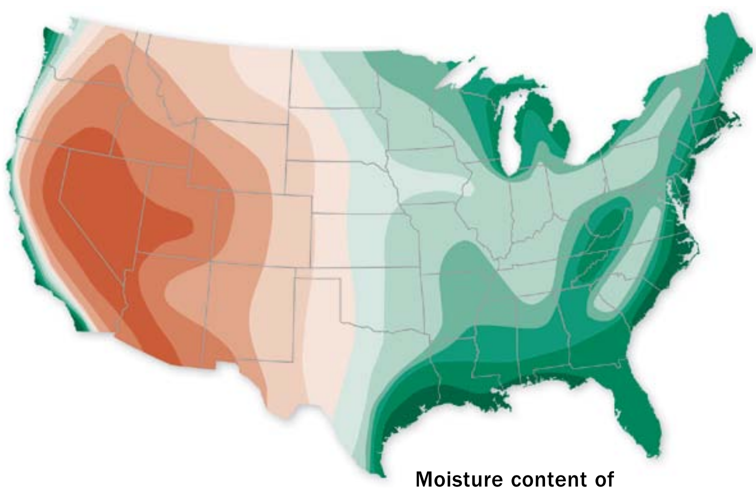
Using the meter. *Today's meters are simple to calibrate for a wide range of species. The pins leave holes in the wood, so find a waste area to place them in. Take readings on the face of the board. Stay an inch or two away from knots.*

3. ANTICIPATE FUTURE HIGHS AND LOWS

The maps below will help U.S. woodworkers to predict future high and low EMCs for their region of the country, but this is another area where a moisture meter adds precision. If you live outside the map area, or in a micro-climate such as near a body of water, you can gauge the swings very accurately by doing your own seasonal testing of lumber in your shop, and also some tests on the backs or bottoms of furniture in the home. This will not only reveal the highs and lows for your neck of the woods, but also how much the moisture levels in your shop tend to vary from those in the house.

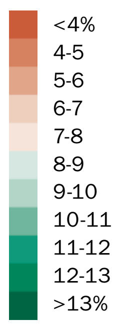


Moisture content of interior woodwork in January



Moisture content of interior woodwork in July

Moisture content (%)



SEASONAL MOISTURE CONTENT MAP

In most of the United States, the average MC of interior woodwork varies from winter to summer. It's those seasonal changes that cause wood to shrink in winter and expand in summer.

Handy chart does most of the work

There are a number of ways to convert shrinkage rates to actual dimensional changes, based on the factors listed here, and the math can be complex. So I've created a chart that makes the math simpler. It gives the amount of movement per inch, based on a given shrinkage rate and the amount of change you expect in the MC.

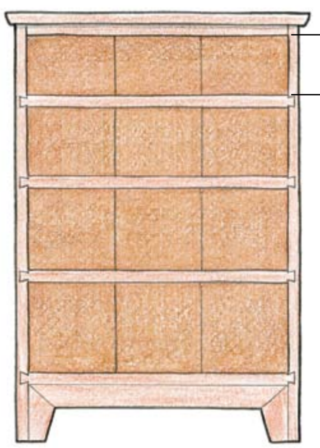
To get the change in dimension, start with the current MC of the board, plus its estimated shrinkage rate, based on its species and grain orientation (see chart, p. 84). Then use the regional maps to determine what the MC will be during the muggiest and driest months. The difference between the current MC and the high and low MCs for the year can be plugged into the chart below to get the expected dimensional change per inch of width. Then just multiply that by the width of the board in question.

By the way, though the numbers on the chart are five places to the right of the decimal point, and will yield what appears to be a very precise value, it is just an approximation. So err on the safe side when picking a final number for expected dimensional change.

Let's work through a specific example to see how this process works in practice.

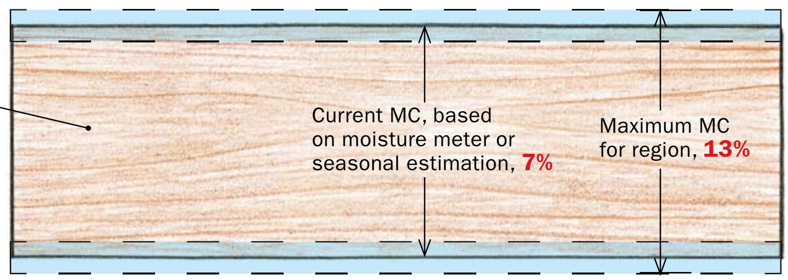
CALCULATING A DRAWER GAP

To figure out how much of a gap to leave at the top of a drawer, do the following math. Then add 1⁄32 in. to your answer, to make sure there is still a thin gap at the top in the most humid season.



1. Consult the shrinkage rate chart on p. 84.

2. Estimate current MC and maximum MC using seasonal MC maps on p. 85.



WOOD MOVEMENT PER INCH				
SHRINKAGE RATE	CHANGE IN MOISTURE CONTENT			
	2%	4%	6%	8%
2%	0.00143	0.00286	0.00429	0.00571
3%	0.00214	0.00429	0.00643	0.00857
4%	0.00286	0.00571	0.00857	0.01143
5%	0.00357	0.00714	0.01071	0.01429
6%	0.00429	0.00857	0.01286	0.01714
7%	0.00500	0.01000	0.01500	0.02000
8%	0.00571	0.01143	0.01714	0.02286
9%	0.00643	0.01286	0.01929	0.02571
10%	0.00714	0.01429	0.02143	0.02857
11%	0.00786	0.01571	0.02357	0.03143
12%	0.00857	0.01714	0.02571	0.03429

3. Consult the wood movement chart at left to find the expansion factor.

Shrinkage rate: **7%**
Change in MC: **+6%**
Expansion per inch: **0.015 in.**

4. Multiply expansion factor by height of drawer to predict actual expansion.

0.015 in. x 6 in. = 0.09 in.

5. Add 1⁄32 in. to predicted expansion and round upward for safety. The answer is the current gap needed at the top of the drawer.

0.09 in. + 1⁄32 (0.03125) = **0.12125 in.**
Round up to nearest fraction: **1⁄8 in. (0.125)**