

## Introduction

Over the decades, I've come to appreciate that woodworking isn't as formal and precise as one might believe. That's a good thing: it plays to our artistic nature and allows us to be inventive. The most creative worker of wood whom I've ever met was Sam Maloof. That's Sam in the photo below (seated), at the Anderson Ranch in Colorado



around 2004. I'm the well-fed guy on the left, and the woodworking program director at the Ranch back then, Susan Working, is on Sam's right. His shop foreman, Mike Johnson, and Mrs. Maloof are standing behind him.

Over the years, Sam helped me with interviews, quotes and photographs for various publications (my favorite was a profile of him that I did for *Woodcraft* magazine in the May 2005 issue). He was a truly nice person – kind, considerate, generous and humble, and an absolute font of knowledge.

One of the most impressive aspects of his professional work was that he free-formed. Sam rarely used a tape measure. When he switched on the band saw, he closed the owner's manual and used the machine as a carving tool. Students would sit mesmerized through his introduction as he spoke of the relationship between form and function, and then they would sit bolt upright when he turned on the saw and began to free-form legs and other curved parts without fences or formal guidelines.

Sam was still working into his nineties.

When you begin to work wood, it's essential that you study and understand the nature of the materials, and the tools. The key is to be creative in a somewhat cautious manner – to allow your inner artist to emerge in a way that lets you keep all your fingers.

Blades can bite. But Sam understood that they can also sing.

Listen to your own tune...

The following concise summary provides a woodworker with the basics of what he/she needs to know about the way that wood behaves, and why it does so. It also suggests techniques to deal with common problems. There's enough information here to get you up and running, and to help you avoid most of the common problems that new woodworkers come across.

Some of the best woodworkers I know are women. Cindy Drozda and Beth Ireland immediately come to mind. But just to make life a little easier for my fingers, I'm going to be politically incorrect and say 'he' instead of 'he/she' throughout the rest of the book.

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Wood is a natural material, so no two boards are identical – or entirely well behaved. Even the most defect free piece of heartwood can give you a little bit of trouble.

There's our first technical term. **Heartwood** lies at the center of the tree trunk and it is surrounded by **sapwood**, which is just inside the bark. Heartwood is essentially dead, and the growth in a tree's girth takes place in the sapwood. Virtually all of the tree's nutrients and water will travel through the sapwood in the form of, well, **sap** (hence the name).

In most harvested species, heartwood is almost free of knots and defects. It is also a different color tone – either lighter or darker than the sapwood. When a furniture builder is ordering lumber, he can specify that he wants "all heart". He'll pay a premium price, but some of that is recouped when he doesn't have to work around defects. Plus, heartwood is usually specified for higher-end projects, so the price the woodworker charges will reflect that.

### Types of Wood

Just about everyone has heard the terms **softwood** and **hardwood**. These have absolutely nothing to do with how soft or hard a piece of wood is. Balsa (the hardwood used to make model airplanes) is light as a feather and can be crushed with one's bare hand. Old growth fir, a softwood that was used for flooring throughout nineteenth century homes in cities such as Chicago and Minneapolis, is tough as nails and still going strong a hundred years later.

Hardwoods in northern latitudes such as the U.S. lose their leaves in winter. (In the tropics, they don't.)

Hardwoods are said to be **deciduous**, a word that the Oxford English Dictionary™ says is a late 17th century term derived from the Latin word 'deciduus', which means to fall down or off.

Softwoods reproduce with cones (such as pine cones), and are therefore called **coniferous**. Softwoods are most commonly sold as **dimensional lumber** (2x4, 4x4 and so on) that is used in construction, while hardwoods are sold by the **board foot**. Both are used to make moldings.



*Hardwoods and softwoods can grow side-by-side. The winter scene above was photographed in the northeastern corner of Wyoming near Beulah, and shows scrub oak (bare) and evergreens such as juniper and pine (with needles), sharing space with some deer.*

### **Board Feet**

A board foot is a volume of lumber that is the equivalent of one foot long, one foot wide and one inch thick.

For example, a six-inch wide board that is two inches thick and a foot long would hold one board foot of volume.

To work out the board feet of a piece of lumber, simply reduce the three dimensions (width, thickness and length) to inches and then multiply them by each other. Divide the result by 144 and you're done.

If that 2x6 mentioned a minute ago was 5 feet long, it would contain 5BF of lumber.  $2 \times 6 \times 60 = 720$  cubic inches. Divide that by 144 to reduce the cubic inches to cubic feet, and the result is 5.

That's really all there is to it.

The arithmetic holds true for any hardwood dimensions. For example, a board that is 5 inches wide, 1 inch thick and 14 feet long will be 5.83 BF. ( $5 \times 1 \times 168$ , divided by 144 = 5.83)

### **Shrinkage**

Lumber is measured **in the rough**. A rough board is one that has just come off the sawmill, where it was harvested from a log. It hasn't yet been dried (more on this in a minute), or planed.

A softwood 2x4 is nominally two inches thick and four inches wide after it is sawn. Drying it in a **kiln** and then planing it will reduce it to 1-1/2 inches thick and 3-1/2 inches wide. Even though every piece of framing lumber doesn't need that much planing to be nice and straight, carpenters need all of the studs in a wall – or the rafters in a roof – to be pretty much the same. So the industry has settled on a formula that allows the mill enough waste to ensure that virtually any board can be dried and then cleaned up to meet these dimensions:

1 inch becomes 3/4.	7 inches becomes 6-1/4.
2 inches becomes 1-1/2.	8 inches becomes 7-1/4.
3 inches becomes 2-1/2.	9 inches becomes 8-1/4.
4 inches becomes 3-1/2.	10 inches becomes 9-1/4.
5 inches becomes 4-1/2.	11 inches becomes 10-1/4.
6 inches becomes 5-1/2.	12 inches becomes 11-1/4.

Note the difference after 6 inches? The wider boards lose  $\frac{3}{4}$  of an inch, while the narrower ones only lose  $\frac{1}{2}$  an inch. That's because of shrinkage. When a softwood board is dried in a kiln, it loses a lot of **moisture** and shrinks quite a bit. Most softwood is dried for a few days, while hardwoods can be cooked for over a month, depending on the type of kiln. There are exceptions.

There are two types of moisture in freshly harvested wood. **Free water** slops around inside the hollow cells (the lumen), and **bound water** is inside the cell walls, held there by a hydrogen bond. A short time in the kiln will remove most of the free water. This will bring most lumber down to about 20% **moisture content** (MC). In the Western states and Canada, where most of our construction pine and fir grow, the mills kiln dry to about that level, and then let the high mountain air evaporate some of the bound water until the boards are somewhere between 8% and 12% MC. Moisture is expressed as a percentage of weight. The number tells us how the weight of the water in a board relates to the weight of the wood in the same board. For example, if the wood weighs 80lbs and the water weighs 20lbs, then the MC is 25%.

Let's do that again.

The board without any moisture whatsoever weighs 80lbs. But because trees are essentially drinking straws that suck water out of the ground and deliver it to the leaves, the cells of the trunk and branches will always have lots of water in them when freshly cut – in most cases, the weight of the water will be almost as much as the weight of the wood. When the trunk is made into boards, a lot of that water is still there. Let's say that, after a few days in a kiln, the water is reduced to the point where it only weighs 20lbs. Well, 20 is one quarter of 80, so the water weighs one quarter (25%) as much as the wood. The MC is 25%.

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Trees can have moisture content over 100%. That is, the water in the tree as it's growing in the woods can outweigh the actual wood in the tree. While some species can reach 150% MC, most don't. For example, white oak and scrub oak are generally about 65% MC, while red oak is a bit higher (75% or so). MC can vary a little depending on the time of year: there's more growth and thus a little more water in spring than fall, but the difference is marginal.

Knowing the MC is important to woodworkers for two big reasons. People who transport lumber can carry almost twice as much kiln-dried product as they can **green** (wet) boards, because of road and axle restrictions. That makes a difference when it comes to the price we pay in the stores: freight is a major factor in lumber pricing because wood is large, unwieldy and heavy. But the second reason is more important: **movement**.



*A crew removes dead limbs from a cottonwood tree adjacent to Highway 85 in Belle Fourche, South Dakota (2015, photo by author). Not all hardwoods make great furniture. Cottonwoods are thirsty trees and the wood is unstable and relatively bland, so it has limited structural integrity or visual appeal. Nonetheless, prairie homesteaders often had no other choice but to build their log cabins from cottonwood, and many of those structures have survived for more than a century.*

As boards gain or lose moisture, they expand and shrink. And woodworkers need to design and build with that in mind.

But before we get into that, let's see how the industry measures hardwoods...

### **Measuring Hardwoods**

Hardwoods are not dimensioned, with one notable exception. If you buy them at a big box store, many of those outlets have adopted the softwood rules because hobbyists are familiar with them. You can buy, say, a 1x4 that is eight feet long in a good grade of oak or maple, often nicely wrapped in clear plastic. You're also paying about twice the industry price for that board. If at all possible, go to a hardwoods supplier or a local sawmill to buy.

Hardwoods are not sold as dimensional lumber for several reasons. They tend to be used in much smaller volumes than studs and rafters, and because they are relatively rare and command a big price, the industry tries to minimize waste.

When you go to a hardwoods specialty store, some of the boards will be S2S and SL1. That means they will be **surfaced** on two sides and **straight-lined** along one edge.

Surfacing means planing. If the store is dealing with professional woodworkers, the planing won't be full surfacing: it will be what is known as '**hit-and-miss**' (H&M). The knives will remove as little as possible from the thickness of the board, and will let the woodworker clean up the faces and reduce the thickness to his own needs. H&M planing will be just enough to see the grain and color, and the board will probably still have some saw marks.

Technically, S2S is a misnomer. One can't plane two sides of a board, because there are no sides in woodworking. The word is just too confusing: what exactly is a side? So, woodworkers talk about the wide surfaces as **faces**, and the narrow ones as **edges**.

Straight-lining means that one or both edges have been made straight, and these are theoretically true enough to run against a fence and be ripped on a table saw. But wood moves, and by the time you get to the saw, the line may no longer be straight and may need to be jointed. *Board edges that will run against a fence must be straight.*

In addition to surfaced and edged boards, the yard or mill may also offer rough-sawn stock, which is fresh from the saw and kiln. Here, you're buying the full thickness and width, but you can't see the color,

grain or possible defects such as **checking** or **case hardening** (yup, we'll get to them in a bit). It's a gamble, and the best advice is probably to stick with H&M until you have some experience under your belt.

Very little commercial hardwood is air-dried anymore. There are gas, electric, wood-fired and solar kilns that can complete the process in days or weeks, while air drying takes about one year for each inch of thickness.

Hardwood measurement begins with thickness and, outside of the big box stores, that dimension is always expressed in **quarters**. A board that is one inch thick in the rough is termed 'four-quarter'. This is written as 4/4 (no inch marks). So, three-inch thick boards would be 12/4, and a board that is 1-1/4 inches thick is 5/4 (five quarter).

Again, these are all rough-sawn boards, before drying or planing. If you want 3/4-inch thick, nice clean boards to build a project, you can usually start with 4/4 stock.

So, now you know that hardwood is measured in terms of rough boards, and the thickness is expressed in quarters. You know that the faces can be hit-and-miss (sometimes called hit-or-miss) and the edges can be straight-lined. And you know that the volume will be calculated in terms of board feet.

All that's left is the width and length.

Most yards and mills will size boards by width or length for you, but at a very steep price. That is, you can buy all, say, six-inch wide boards, but the cost will be very high. That's because the supplier has to cull (remove) anything less than six inches, or boards that aren't multiples of six. For example, a ten-inch board will deliver one six-inch plank and about 3-7/8 inches of waste (allowing 1/8-inch for the saw-blade **kerf**).

*If you're thinking of working wood as a profession, ask your local library to search the system and find you a copy of my book "Harvest Your Own Lumber" (ISBN 978-1-61035-243-7). It goes into considerably more detail about the properties and nature of wood.*

The same is true of length. You can ask the yard to supply all 8-footers, but they may have to get those from 12 or 14-foot long boards, and there isn't much of a market for the 4 or 6-foot long waste, which are usually called shorts.

The best way to buy is in **random widths and lengths**, and it usually pays to specify a minimum length. Boards can always be jointed and edge glued back in your shop to make them wider, but it's pretty much impossible to make them longer.

Talk to your supplier about his definition of random. He might have rules that work for you, such as nothing less than 8 feet long or 4 inches wide. The hardwood flooring industry often uses the term 'random width' incorrectly to describe a package where tongue-and-groove flooring comes in three or four predetermined fixed widths (perhaps 2, 3 and 6 inches), so it can be installed in a pattern. This is actually mixed or varied width. True random width lumber comes in the width that the log and the sawmill determined.

Most mills sort the lumber into narrow, medium and wide boards, and then create pallets (bunks) of these, because that's what their customers usually need. However, some mills will sell also logs in **flitches**. This is a term borrowed from the veneer industry, and it means that you can buy the entire log after it has been cut into slices and then re-stacked exactly as it was before sawing. Buying a flitch is one way to ensure great color matches, and some furniture builders can do amazing things with the repeated grain patterns.