



How Much Wood Is That?

Introduction

Timberland owners can sell standing trees (stumpage) or pay for a logger to harvest them and transport them to a mill (delivered logs). (It is also possible to sell logs by the side of the road (roadside), but this is not very common with institutional investments in the US).

Selling wood should be simple. Wood can be sold by weight or by volume. How difficult can that be? But, what unit of weight or volume should you use? One buyer will pay \$30/ton. Another will pay \$350/MBF. Which price is better?

Units

Harvested logs and processed wood can be measured by weight or volume and will be priced accordingly. In most of the world, the unit of weight is the metric tonne and the unit of volume is the cubic meter.

The timber growing and forest products industries in the United States enjoy(?) a wider variety of units. The most common unit of weight is the ton (2,000 pounds), but there is a region in eastern Maine where prices are stated in terms of \$/1,000 pounds (mlb).

Common units of volume in the US include:

- Cord: (a pile of logs, almost always pulpwood, that is 4' (feet) tall, 8' wide and 4' long or 128 cubic feet)
- Board foot: 12" (inches) X 12" X 1" thick, usually expressed in terms of 1,000 board feet (MBF)
- Cubic foot: 12" X 12" X 12"
- Cunit: 100 cubic feet (often used by the US Forest Service, not commonly used in the private sector.)

Measuring by weight is fairly simple, though some of the weight will be in the bark, not the wood.

Measuring by volume more complex. Estimating the volume is trickier because logs are not perfect cylinders.

Pulpwood stacked by the cord includes spaces between the logs and the bark on each log. While the whole pile may measure 128 cubic feet, it is commonly assumed that there will be 85 cubic feet of solid wood in that cord. The amount of empty space in a pile of cordwood depends in part on the average diameter of the logs in it.

When sawlogs are measured, they are usually measured inside the bark. Logs are tapered and so are usually measured at the small end—but to know the precise volume in the log, both ends need to be measured. This is often avoided by using regional assumptions about the average taper for each species and log length.

Weight/Volume Conversion Factors

Whether wood is measured by weight or by volume, somebody always wants to convert from one to the other. How much does a cubic meter of logs weigh? How much does a thousand feet (MBF) of logs weigh? Since there are weight limits on highways, how many MBF of log can be loaded on a truck and not exceed those limits?

The answers are almost as many as there are sources. In general, softwoods are lighter than hardwoods, though balsa and basswood (both hardwoods) are lighter than most softwoods.

Table 1 shows some conversion factors from a number of sources. Note the boxes around sugar maple and red oak highlighting three different conversion factors for each of these species in our files.

Table 1. Selected Conversion Factors (tons/MBF)

	Tons/MBF	
	Softwood	Hardwood
UNFAO	3.65	5.50
Timber Mart-South (southern pine and hardwood)	7.50	8.75
NH Department of Revenue (eastern white pine)	4.30	
TX Forest Service (southern pine and hardwood)	8.00	9.00
Forest Research Group files		
White Ash		5.55
Aspen		5.40
Basswood		4.75
Beech		6.35
Yellow Birch		6.60
Wester Redcedar	3.10	
Black Cherry		5.25
Cottonwood		5.35
Cypress	5.90	
Balsam Fir	5.20	
Douglas-fir	4.35	
Eastern Hemlock	5.60	
Hickory		7.35
Sugar Maple		6.45
Sugar Maple		5.46
Sugar Maple		5.90
Red Maple		5.95
Red Oak		7.40
Red Oak		5.73
Red Oak		6.19
White Oak		7.20
Loblolly Pine	6.20	
Longleaf Pine	5.55	
Sugar Pine	5.75	
Ponderosa Pine	5.65	
White Pine	4.50	

Log Rules

Sawtimber on the stump is usually measured by volume (usually MBF) because it is *very* difficult to weigh a living tree. Sawtimber is often sold by the ton, but there is always a local conversion factor that allows people to work with both volume and weight.

The volume measurement of trees and logs attempts to estimate the volume of lumber than can

Figure 1. Hypothetical Diagram Log Rule

Left: the small end (12") of an 8' log. Middle: 2x4s drawn on the small end. There are 12 2x4s measuring 64 board feet. Right: 2x4s drawn on an 8', 18" log. There are 30 2x4s measuring 160 board feet.



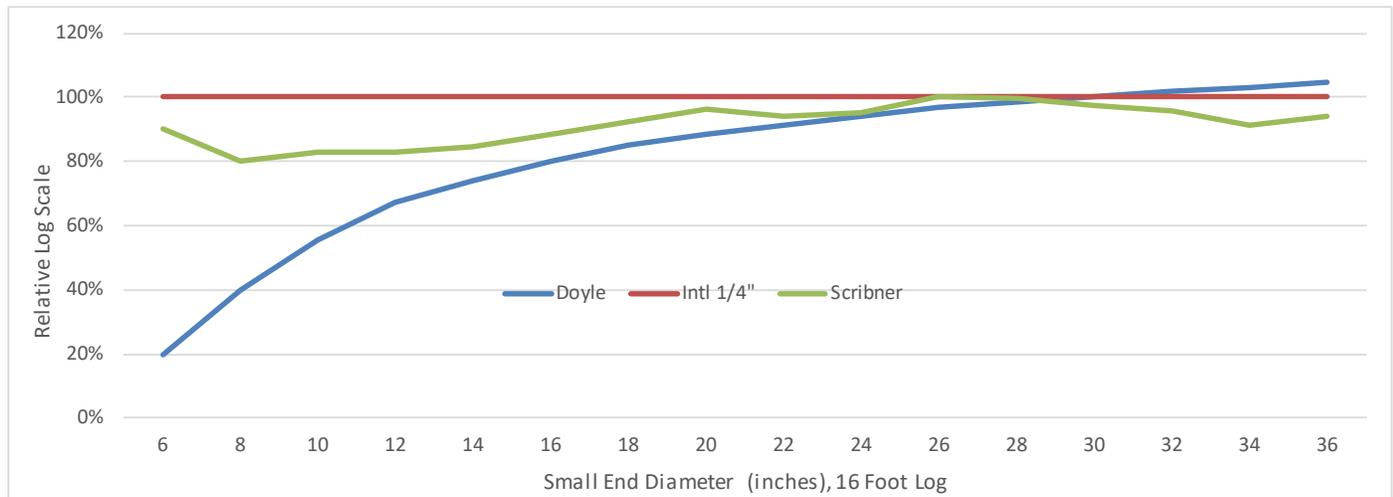
be produced from them. This is difficult because logs are round and tapered, while lumber is square or rectangular and is not supposed to taper.

Many log rules have been developed to estimate volumes. Freese (1972) found nearly 200 have been used over the past 200 years in the US and Canada. There are three basic ways to develop a log rule:

- Mill scale rules are developed by running a series of same-sized logs through a mill and measuring the volume of lumber produced from each log-size group.
- Diagram types are made by drawing a set of squares and rectangles in a circle (Figure 1). The developer must make assumptions about log taper, sawing method, thickness of the saw blade and thickness and width of the lumber produced.

The Scribner rule is a widely used diagram rule. It assumes a 1/4" saw kerf (the wood lost to sawdust as the saw cuts through the log) and all 1" thick lumber. A thinner saw (e.g., 1/8") would produce more lumber and more lumber can be recovered if 2" lumber is being sawn because there are fewer saw cuts (less kerf).

Figure 2. Log Rule Comparison for 16-Foot Logs



Source: Freese, 1972

- Formula-based rules are, as the name suggests, based on formulas. Two widely-used rules are Doyle and Intl 1/4”.

The Doyle rule formula is:

$$BF = (D-4)^2 * L/16$$

Where:

D = diameter

L = length

The Intl 1/4” rule assumes a log tapers 2” per 4-foot section of log and uses a slightly different formula logs of different length.

The formula for a 16-foot log is:

$$BF = 0.796D^2 - 1.375D - 1.23$$

Why are there so many log rules? Because all them have short-comings. They over-or under-estimate the volume in the log at one end of the diameter range or the other. Figure 2 compares the Doyle, Intl 1/4” and Scribner rules. If we assume (just for now) that Intl 1/4” gives the most accurate estimate of the board feet of lumber that would be recovered from the log, the chart shows that the Doyle rule provides a much lower volume estimate—20% of the Intl 1/4” estimate for a 6” diameter log and 55% of the Intl 1/4” estimate for a 10” log.

If we assume a price of \$350/MBF, the value of a Doyle-scaled 10” diameter, 16’ long log would be:

$$36 \text{ BF} / 1,000 \text{ BF/MBF} \times \$350 = \$12.60$$

Table 2 shows the same calculation for all three log rules.

Table 2. How NOT to Value a Log Using Different Log Rules

Log Rule	BF/10" dia log	Price (\$/MBF)	Calculated Price/Log
Doyle	36	\$350	\$12.60
Intl 1/4"	65		\$22.75
Scribner	54		\$18.90

The table suggests that landowners would prefer to sell their timber using the Intl 1/4” rule (highest value), while mills would prefer to buy their timber using the Doyle rule (lowest value). But buyers and sellers don’t get to choose their preferred log rule--the area in which they are located will have a locally preferred rule.

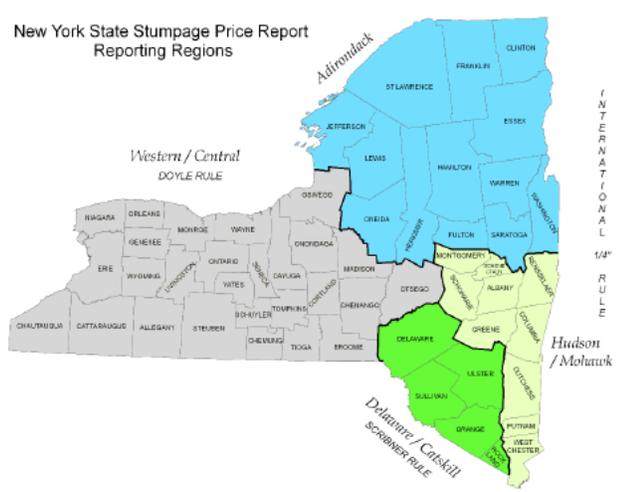
The volume of lumber that would actually be made from the log is the same regardless of the log rule used. Since “everybody knows” that the Doyle rule provides a lower volume estimate for smaller logs, we might expect the Doyle \$/MBF price to be higher than the Intl 1/4” price. Table 3 uses the relative log scale from Figure 2 to calculate prices for each log rule using the Intl 1/4” price as a base. Note that, while the \$/MBF prices for Doyle and Scribner are higher than for Intl 1/4”, the value of the log (BF X \$/MBF / 1000) is the same.

Table 3. Estimating Prices Using Different Log Rules

Log Rule	BF/10" dia log	Relative Scale	Intl 1/4" Price (\$/MBF)	Calculated Price (\$/MBF)	Calculated Price/Log
Doyle	36	55%		\$632	\$22.75
Intl 1/4"	65	100%	\$350	\$350	\$22.75
Scribner	54	83%		\$421	\$22.75

Does this really work in the real world? Yes—sort of. The State of New York publishes prices for four different regions using three different log rules (Figure 3). Table 4 compares the calculated price in Table 3 with three prices published in the July 2018 NY report. (The Intl 1/4" price in the table is from the Adirondack region.)

Figure 3. NY Price Report Regions



Source: NY Division of Lands and Forests

The prices for hard maple and red oak support our calculations in Table 3. The Doyle prices are 50% and 55% higher than the Intl 1/4" price, respectively. The Scribner prices are 61% and 74% higher than the Intl 1/4" price.

Why aren't they exactly the same as the relative scale? And what happened with white pine? The answer to both questions is that the markets are interfering with our theory. Our relative scale assumes a 10" dia, 16' log. The average log size in the woods may be different. The market for white pine in the Adirondack region appear to be different than in the other regions. This could be due to differences in supply, demand and quality among the regions.

Table 4. Comparing the Estimated Price to Published Prices

Log Rule	Calculated Price (\$/MBF)	NY Hard Maple Stumpage	NY Red Oak Stumpage	NY White Pine Stumpage
Doyle	\$632	\$700	\$700	\$60
Intl 1/4"	\$350	\$350	\$400	\$115
Scribner	\$421	\$575	\$540	\$80

Log Rule Conversion Factors

Some price sources publish conversion factors (Table 5), but note that the published conversion factors assume an average log size (not always specified).

Table 5. Log Rule Conversion Factors

	Relative Scale	PA	Timber Mart-South
Doyle	55%	59%	62%
Intl 1/4"	100%	100%	100%
Scribner	83%	86%	83%

Sources: PA Cooperative Extension Service, Timber Mart-South

Summary

Measuring wood is a complex process in the US. Wood can be sold by weight or volume and prices can be quoted either way as well. The weight per unit (e.g., tons per MBF) will vary by species. When comparing prices among regions it may be necessary to convert from one log rule to another.

Is it really surprising that most of the world prefers to use cubic meters and metric tonnes for everything?

References

Freese, Frank, 1972, A Collection of Log Rules, US Forest Products Laboratory, General Technical Report FPL-001

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Jack Lutz, PhD
Forest Economist
Forest Research Group
78 Stonybrook Way
Hermon, ME 04401
(207) 605-0037

jlutz@forestresearchgroup.com