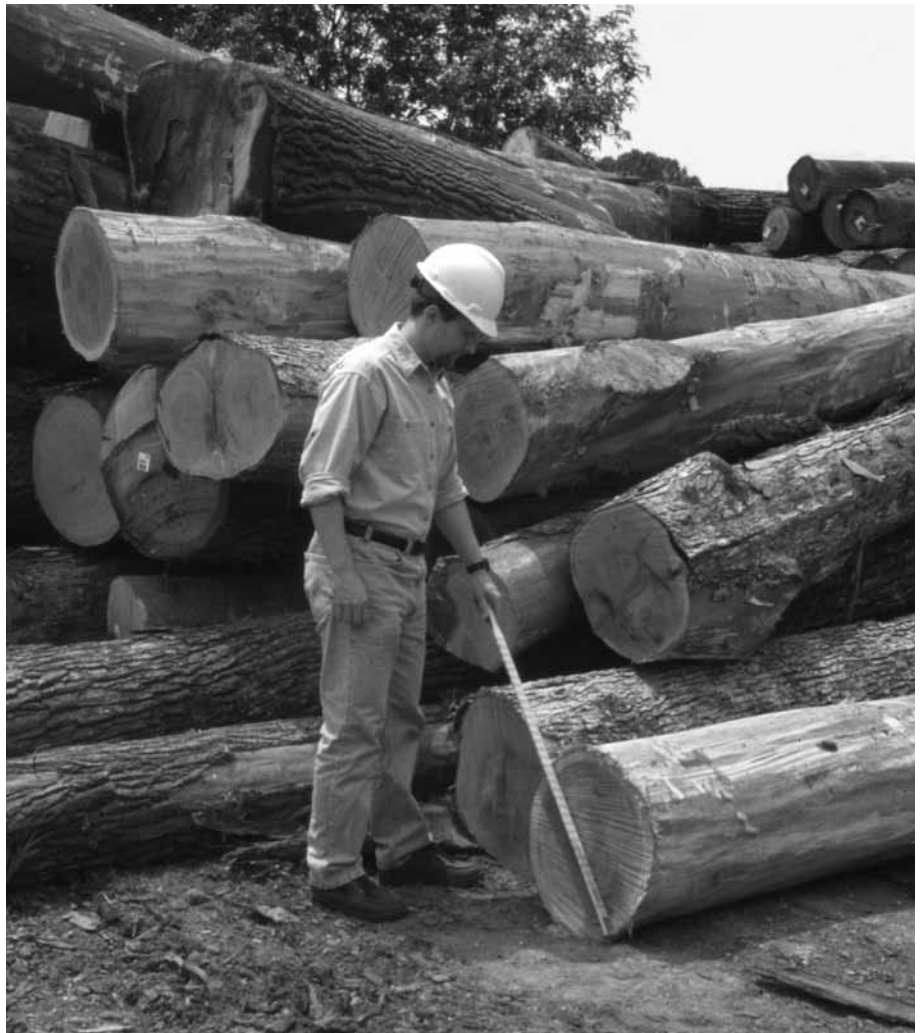# Understanding Log Scales and Log Rules

Understanding Log Scales and Log Rules

Brian Bond, Former Assistant Professor, Forestry, Wildlife and Fisheries

Introduction

A necessary step in determining the value of timber at the mill is establishing the estimated volume by standard scaling practices. Examples of scaling practices include measuring the weight of pulpwood to estimate the volume and measuring the dimensions of hardwood sawlogs, along with applying a log rule to determine how much lumber can be sawn from the log. This publication describes common methods of log scaling and log rules used in Tennessee.

Scaling estimates the log volume on a board foot, cubic foot, linear foot or cord basis. In scaling pulpwood or chipwood, the volume of available material is usually estimated from the weight of the product, where moisture content, species and other factors are considered. For logs that are to be processed into lumber, log rules are usually applied to estimate the total volume (expressed in board feet) of lumber that can be sawn. A board foot is equivalent to a 1 inch thick by 12 inches long by 12 inches wide, or a 144 cubic-inch piece of wood. Scaling methods are *estimates* of volume; therefore, variability exists between the different methods based on log shape, density, size, taper, moisture content and human error.

Purpose of log scaling

Log scaling determines the quantity of wood and is done primarily to determine the value of individual logs. Scaling also is used to maintain accountability for paying loggers and landowners, to evaluate the financial performance of a sawmill, to ensure the quality of logs entering the mill yard, to assist in inventory and quality control, and to allow tracking of mill efficiency.

Methods of log scaling

There are several common methods for estimating the volume of wood available in a log. These include board-foot scaling, cubic volume scaling, weight scaling and electronic scanning. Due to differences in how each scale incorporates size, taper, moisture content, density, etc., it is difficult to accurately convert volumes between scaling methods.

1. Weight-scaling methods

Weight scaling is often applied to pulpwood, chipwood and Southern pine sawlogs, and has recently begun to be used with hardwood saw logs. Weight scaling is usually done by first weighing log trucks that are fully loaded and then weighing the truck again when empty to determine the weight of the load. The weight can be converted to an equivalent board foot or cord volume if desired. Many companies use standard weight-scale factors for pricing, and some develop their own factors based on their product mix. Weight-scale factors vary with timber quality, density, moisture content and mill efficiency. An example of weights and volumes for Loblolly Pine is given in Table 1. Forest site differences effect wood density; therefore, weight scale factors vary with different geographic locations.

The benefits of weight scaling are that it reduces scaling costs, requires less handling of logs,

Table 1.			
Weight ranges for loblolly pine where MBF is a thousand board feet.			
Lbs. per cord	Tons/cord	Lbs. per/MBF	Tons/MBF
5,000-5,600	2.5	19,000-22,500	9.5

are not perfect cylinders, so each rule uses a different method to estimate the volume of a tapered, imperfect cylinder. Most log rules were developed prior to the 1930s, so they do not account for modern sawmill technology (thinner saw kerfs, better equipment, etc.), often underestimating today's actual yield.

encourages prompt delivery after harvesting and is completed quickly. However, this method does not consider log quality or species mix, log diameter, length and soundness. These factors are very important to landowners and sawmills. For example, a load of larger, longer and more sound logs will produce significantly more lumber than will a load of the same weight with more logs that have smaller diameters and shorter lengths, yet the price paid for each will be the same.

2. Electronic methods

Electronic measures of log volume use light curtains or lasers to measure log diameter, length and taper. These measures of log volume are very accurate and efficient. They are often used for automated selection of an optimized sawing pattern for maximizing yield in a sawmill. The main drawback of this method is the expense of the equipment required. Electronic volume scanners are used extensively in large Southern pine sawmills and are gaining favor in hardwood sawmills.

3. Board-foot log scaling methods

Board-foot log scaling methods have traditionally been the standard used with the industry and are still the most commonly used. This method estimates the volume of lumber that can be sawn from a log on a board-foot basis and requires that each log be scaled according to a specific log rule. A log rule is a mathematical formula or table that gives an estimate of the net yield of lumber in board feet for logs given a specific diameter and length. Log rules generally have allowances for losses in yield due to saw kerf, producing slabs, edging and shrinkage. More than 95 log rules are recognized in the US and Canada. Each log rule is different because of the way log taper, saw kerf, slabbing, edging and other manufacturing variables are calculated. Logs

Common log rules

The three most common rules are the Doyle, Scribner Decimal C and International $1/4$-inch. Figure 1 displays the differences between the amount of lumber that can be sawn from a log versus the estimated scale for the rules discussed. The International $1/4$-inch rule is used as the base. The history, derivation of the rule and differences between rules are discussed below.

1. Doyle Log Rule

The Doyle rule is the most common rule used in hardwood log scaling in Tennessee. Edward Doyle developed this rule prior to 1850. This rule estimates the volume based on log length, diameter, slabs, edgings, shrinkage and production of sawdust. The allowance for slabs and edgings is too large for small logs and is too small for large logs. Also, the rule allows for only a 4.5 percent reduction of log volume for sawdust and shrinkage where most rules allow between 10-30 percent. There is no allowance for taper.

The formula used in estimating lumber volumes using the Doyle rule is

$$\text{Log Volume (bd. ft.)} = \frac{(D-4)^2 L}{16}$$

where D is the diameter inside the bark measured in inches at the small end of the log and L is the nominal log length measured in feet.

2. Scribner Log Rule

J. M. Scribner developed the Scribner log rule in 1846. This rule is based on a series of diagrams outlining the sawing pattern for 1-inch lumber for each diameter and length class with a $1/4$-inch allowance for saw kerf. Taper is not accounted for in the rule, so it under-estimates volumes for logs more than 16 feet in length. One disadvantage of this rule

is that there is no uniform slab allowance for log diameters.

A change was made to the basic Scribner rule in the early 1900s to make it easier to apply. This new rule is known as the Scribner Decimal C rule and is different from the standard Scribner rule in that all volumes are rounded to the nearest 10 board feet. For example, a log that scales 64 board feet would be rounded to 60 board feet. This rule is commonly used on the West Coast and in the South for pine saw logs.

A formula which closely estimates the Scribner rule is

$$\text{Log Volume (bd. ft.)} = (0.79D^2 - 2D - 4)\frac{L}{16}$$

where D is the diameter inside the bark measured in inches at the small end of the log and L is the nominal log length measured in feet.

3. International $^1/_4$- inch Log Rule

Judson C. Clark originally developed this formula-based rule around 1906 as the International $^1/_8$-inch rule. In 1917 he developed the International $^1/_4$-inch rule, which increased the saw kerf allowance to $^1/_4$-inch in the formula. This $^1/_4$-inch rule is the form used today. The rule is based on analysis of losses that occur during the conversion of sawlogs to lumber and is one of the few rules that incorporates taper. The rule assumes a taper of $^1/_2$

inch in 4 feet. All calculated values are rounded to the nearest 5 board feet. This rule is generally used in timber sales in eastern national forests and state forests in Tennessee. This is the most accurate rule of the three discussed.

The formula used in estimating lumber volumes using the International $^1/_4$-inch rule is

For 4-foot lengths: $BF = (0.199D^2 - 0.642D)$
For 8-foot lengths: $BF = (0.398D^2 - 1.086D - 0.27)$
For 12-foot lengths: $BF = (0.597D^2 - 1.330D - 0.72)$
For 16-foot lengths: $BF = (0.796D^2 - 1.375D - 1.23)$
For 20-foot lengths: $BF = (0.995D^2 - 1.221D - 1.72)$

where D is the diameter inside the bark measured in inches at the small end of the log and BF is board feet.

Selecting a Log Rule

Of the three rules discussed, the Doyle rule is the least accurate in lumber volume estimation. The rule's inaccuracies are due to the method by which slabs and edgings are accounted for and the lack of allowance for log taper. This rule under-scales small logs and overscales large logs. The main reason this rule is used so often in Tennessee is that it has been used for scaling hardwood logs for so long that the volumes the rule gives have become the standards of value. The errors associated with the rule are usually well understood by

Table 2.
Comparison of the stumpage value of logs for each log rule using a sample of oak logs 12 feet in length, where BF is board feet and MBF is a thousand board feet.

Diameter	Doyle rule	Scribner rule	International $^1/_4$- inch rule
1 0″	27 BF	40 BF	45 BF
1 4″	75 BF	86 BF	100 BF
2 0″	192 BF	210 BF	210 BF
Estimated total board feet	294 BF	336 BF	355 BF
Stumpage value per MBF	$298/MBF	$223/MBF	$185/MBF
Total stumpage value	$88	$75	$65

both the buyer and seller of logs so the prices paid for logs are adjusted appropriately. Table 2 shows the differences in prices paid for a volume of logs for the three log rules discussed.

The Scribner rule is an intermediate estimator of lumber volume for logs less than 28 inches in diameter and less than 16 feet in length. Its inaccuracies come from the lack of allowance for log taper and a uniform slab allowance for different log diameters.

The International $1/4$-inch rule is the most accurate of the rules discussed; however, it is not as commonly used in Tennessee because of the familiarity with the Doyle rule. The log rule used will vary for different areas within the state. In rules that scale low, the adjustment is usually made by increasing the cost per thousand board feet for logs. Often, such rules have been used for scaling hardwood logs for so long that the volumes the rule gives have become the standards of value. An example of this is the common use of the Doyle rule. The rule used is commonly chosen based on the tradition of an area rather than the rule's accuracy in volume estimation.

Due to the differences in volume estimation (as seen in Table 3) and difficulty in converting between log rules, the buyer and seller of logs should agree on the scale to be used and be consistent with its use. When using a contract, the seller usually dictates the log rule used.

Some common conversion factors between rules for sawtimber price estimates are listed below.

To convert sawtimber *prices* from:
- Doyle to Scribner, multiply Doyle prices by .75
- Scribner to Doyle, multiply Scribner prices by 1.33
- Doyle to International, multiply Doyle prices by .62
- International to Doyle, multiply International prices by 1.6
- Scribner to International, multiply Scribner prices by .83
- International to Scribner, multiply International prices by 1.2

Applying a Log Rule

Scaling a log is a matter of measuring the average diameter inside the bark at the small end of the log, measuring the length of the log and using the log rule to determine the gross scale and then deducting defect volume to attain the net scale. In determining the diameter when log ends are not round, two measurements are taken and averaged. Log diameters are tallied to the nearest inch. For example, a 12 $1/4$-inch diameter is tallied as a 12-inch diameter and a 12 $3/4$-inch diameter is tallied

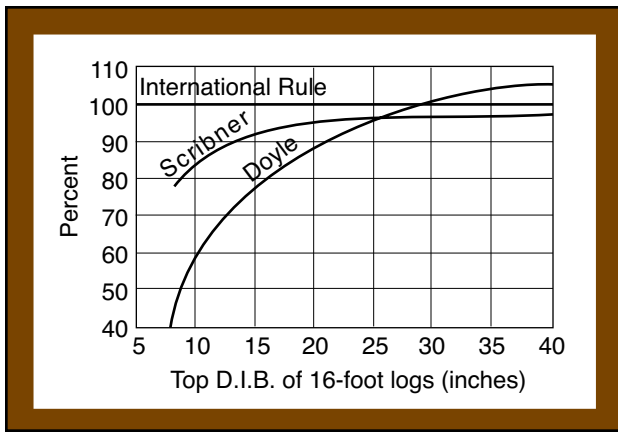| Table 3. Comparison of board foot volumes for the Doyle, Scribner and International $1/4$ - inch log rules based on 16-ft. logs.			
Small-end Diameter (inches)	**Doyle Rule**	**(Volume in Board Feet) Scribner Rule**	**International $1/4$ -inch Rule**
6	4	18	20
8	16	32	40
10	36	50	65
12	64	79	95
14	100	114	135
16	144	159	180
20	256	280	290
25	441	459	460
30	676	657	675

Figure 1. *The relationship of the International* ¹/₄*-inch,* *Scribner and Doyle log rules for 16-foot longs. The* *International rule is used as the standard of comparison.* *D.I.B is the log diameter measured inside the bark.*

as 13-inch diameter. Once the gross scale has been determined, the log must be examined for defects that reduce the volume of wood available for lumber production. Defects that reduce volume and are con-

sidered scalable defects include rot, checks, sweep and crook. Scaling defects should not be confused with grading defects, which are those defects that reduce the value of the material that can be sawn from the log. Examples of grading defects are knots, small branches and bumps.

Figure 2 gives examples of the cull deductions used for log defects. Determining scale deductions requires skill and experience. For more information on scale deductions, see the national forest log scaling handbook, Amendment No.6, U.S. Department of Agriculture, Forest Service, 1985. Once scale deductions have been determined, they are subtracted from the gross scale to obtain the net scale. The net scale is the estimate of sound volume of a log. The value of the log should be attained using the net scale.

The proper application of log scaling will assist the timber seller and buyer in estimating the value of the final product. When scaling saw logs, be consistent in the rule chosen and understand the difficulties associated with it for volume estimation.
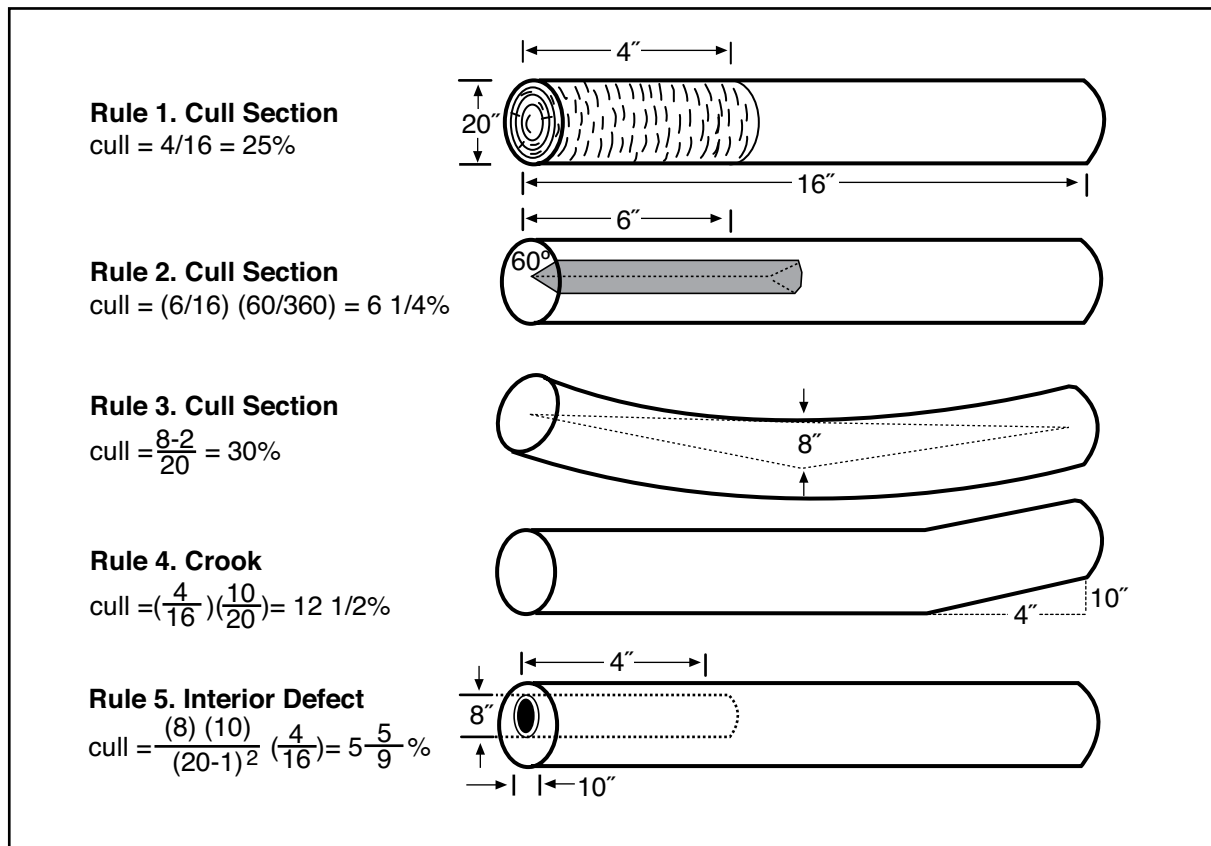

Rule 1. Cull Section
cull = 4/16 = 25%

Rule 2. Cull Section
cull = (6/16) (60/360) = 6 1/4%

Rule 3. Cull Section
cull = $\frac{8-2}{20}$ = 30%

Rule 4. Crook
cull = $(\frac{4}{16})(\frac{10}{20})$= 12 1/2%

Rule 5. Interior Defect
cull = $\frac{(8)\ (10)}{(20-1)^2}$ $(\frac{4}{16})$= 5$\frac{5}{9}$%

Figure 2. *Volume deductions for log-scaling defects.*

By understanding the shortcomings of each rule, you can assure that the proper adjustments are made in the process of value estimation. If you have further questions regarding these measures and values please contact:

Extension Forester
Department of Forestry, Wildlife and Fisheries
The University of Tennessee
274 Ellington Plant Sciences Bldg.
Knoxville, TN 37996-4563
Phone (865) 974-7346
Fax (865) 974-4714
http://fwf.ag.utk.edu/

Visit the UT Extension Web site at
http://utextension.tennessee.edu