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Tree and Log Scales

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Tree and log scaling rules were developed to aid in the buying and selling of trees and logs. The rules provide a method to estimate the volume of wood in the tree or log, and thus assign some value. Trees and logs of sufficient size and quality are sold in units of board feet, and one board foot is 1” x 12” x 12”. The process of scaling measures the tree or log and estimates the volume of board feet. Large quantities of trees and logs are usually sold in thousands of board feet, denoted as MBF where the “M” represents mille the Latin for one thousand.

Because of the history of different log and tree rules within the forest products industry, and the ability to convert from one scale to another, it seems unlikely the state or the industry will undertake an effort to require the consistent use of a single rule. The procedural efforts and policy implications for such a requirement are beyond the scope of this article, but such an undertaking would require considerable effort and time. There are steps owners can take to reduce the frustration and financial risk from dealing with different rules.

An analysis of the various rules may facilitate an understanding of how they relate, and how to avoid confusion and error in their use. A thorough discussion of log and tree rules, summarized here, is provided by Dr. Daniel Cassens, Purdue University Department of Forestry and Natural Resources www.extension.purdue.edu/extmedia/fnr/fnr-191.pdf. Everyone interested in log and tree rules, or scaling timber, would benefit from the study of this bulletin.

Figure 1. Tom Gerow of Wagner Hardwoods explains log scaling and grading to students. Purchased logs are arranged in the log yard to facilitate viewing the log for features of quality and defect (i.e., grading) and to measure log length and diameter of the small end.

The forest products industry is the primary user of these rules. Each sawmill has their favorite rule, and provide details and pricing for the trees and logs they buy based on that rule. Frequent users of rules will either convert volume estimates to their familiar rule, or will know how much over-run or under-run will exist when comparing two rules. The rules each have advantages that argue for their endurance, and disadvantages that cause frustration.

Over the last 200 years, almost 100 rules have been developed and used in the US or Canada. Three rules remain in common use in New York, and most of the Northeast. These include Doyle, Scribner, and International ¼". Doyle and International rules are called formula rules because they were developed based on mathematical formulas. The Scribner rule is a diagrammatic rule because it was developed by creating diagrams of perfect circles to represent the small end of a log and estimating the number of board feet that could be cut. These rules all have the same intended purpose, that being to estimate the number of board feet in a tree or log.

Scaling, the process of estimating volume, considers the geometric shape of the tree or log as a cone because it is roughly circular in cross-section but tapers between the small and large ends (Figure 1). Log scaling involves measuring the diameter on the small end and the length of the log. Tree volume estimates are essentially a series of stacked cones, each successive cone smaller than the preceding cones. Measurement of a cone requires knowing the length of the cone and one or both measurements of diameter for the ends of the cone. Tree measurements are complicated by only being able to easily measure the diameter on one end. Because the upper diameter of the tree's cone is not easily measured, the tree rules assume some amount of taper and use one estimate of diameter.

Figure 2. Estimating the volume of a tree begins with measuring diameter. The most accurate measurement is obtained with a diameter tape, or "d-tape" as pictured. Scale sticks and ocular estimation also provide estimates of tree diameter.

Scaling of logs measures the diameter inside the bark at the small end. Small end measurement accounts for the "saw's perspective" which will cut in a straight line the length of the log. A 16 foot log, for example, will only yield boards that are 16 feet long if they extend the full length of the log. The taper of the log may allow for a shorter, perhaps 8 foot board from the outside of the central cylinder on the thick end of the log. Only the International ¼" log rule accounts for taper. All the tree rules, as described below, account for taper.

Scaling does not directly account for volume lost to defects. If a log or tree has any significant areas of decay, rot, or sweep, the scaler will either make a deduction or will label the estimate as gross volume.

The three common rules have an interesting history and different advantages. Of the three common rules, Doyle is the oldest and most widely used. Edward Doyle likely published his rule in 1825, but the second edition in 1837 is the oldest existing copy. The Doyle log rule is simply:

(Doyle) Board feet per log = (D-4)2 x (L/16), where D is the diameter inside the bark on the small end and L is the length of the log in feet.

The diameter is reduced by 4 inches to account for slabs and edgings, and no adjustment is made for taper. The reduction by 4 inches is excessive for small logs and insufficient for large logs. As a result, the volume of small logs is underestimated, but overestimated for large logs. The advantage and persistence of the Doyle rule is its simplicity and familiarity.

The Scribner rule was developed in the mid 1800's. This rule was diagrammed to produce one-inch thick boards in widths of 4, 6 or 8 inches, and with a ¼" saw kerf. As with Doyle, taper is ignored. Different forms of the Scribner rule were developed, the most common known as "Scribner Decimal C." The complications of a diagrammatic rule were adjusted to some extent, and the yield pattern can be predicted by this formula

(Scribner) Board feet per tree = $(0.79D^2 - 2D - 4) \times (L/16)$, where D is the diameter inside the bark on the small end and L is the length of the log in feet.

Although the Scribner rule is not common, users argue that it has the greatest consistency or precision of the rules.

The International rule was developed in Ontario in 1900 after extensive research into the shape and yield of several northeastern tree species. Of the three rules, it is the most accurate predictor of the yield of lumber from a log based on measurements of log diameter and length. The rule accounts for taper by adding ½ inch of diameter for each 4 foot increment of length. The initial rule assumed a saw kerf of 1/8th inch, but yield was less than expected. By adjusting the formula to a ¼" kerf, yield of lumber better matched predicted volume. The simplicity of the other rules is lost on the accurate but mathematically robust equation for the International ¼" rule:

(Intern'l ¼") Board feet per log = $(0.04976191 \times L \times D^2) + (0.006220239 \times L^2 \times D) - (0.1854762 \times L \times D) + (0.0002591767 \times L^3) - (0.01159226 \times L^2) + (0.04222222 \times L)$, where L is the log length in feet and D is the diameter in inches inside the bark on the small end of the log.

Although this is the most accurate of the rules, Cassens (see previous URL) reports it has not gained acceptance.

As previously mentioned, scaling a tree is similar in many respects to scaling a log. Scaling uses the same principle for measurements that allow estimation of the volume of a cone. Unlike the log, it isn't possible to measure the diameter on the small end of a tree. Also, the thickness of the bark needs to be considered. Finally, disregard for taper of a log will underestimate yield, but disregard for taper on a tree will overestimate yield.

Simple techniques account for these sources of measurement error. First, diameter is measured at a standard height of 4.5 feet above ground, known as "dbh" or diameter at breast height (Figure 2). Second, a tree is categorized into a form class that describes taper. These form classes were developed by James Girard, and describe the diameter at the small end of a 16 foot log as a percentage of the tree's dbh. Thus, for example, Girard form class 78 predicts that small end diameter of a log will be 78% that of dbh. Finally, tree rules account for bark thickness.

While a log's length can be easily measured, the merchantable height of a tree (i.e., the salable portion that is useful for sawlogs or firewood) is estimated with a clinometer, hypsometer, or based on the experience of the forester. An added complication to estimating merchantable height is to decide the location of the smallest usable diameter. If a sawmill only buys logs having a small end diameter of at least 10" or 12", then the forester must estimate merchantable height based on an estimate of where the stem's taper results equals the threshold diameter. The measurements for dbh and merchantable height, usually reported as the number of 16 foot logs, is compared to a table to obtain an estimate of the trees board foot volume. Tables for log and tree rules are available for all three common rules (Figure 3).

A frustration for many woodland owners is the lack of agreement among these rules (Figure 4). The rules have little similarity except for the largest logs. Aside from the different rules leaving woodland owners unsure of tree or log volume, there are consequences to not knowing which rule is used and the behavior of the different rules.

Gross Volume of Trees, International 1/4 inch Log Scale Form Class 78.

DBH	Merchantable height in number of 16-foot logs										
	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2	6
In.	Volume in board feet										
10	36	48	59	66	73	-	-	-	-	-	-
11	46	61	76	86	96	-	-	-	-	-	-
12	56	74	92	106	120	128	137	-	-	-	-
13	67	90	112	130	147	158	168	-	-	-	-
14	78	105	132	153	174	187	200	-	-	-	-
15	92	124	156	182	208	225	242	-	-	-	-
16	106	143	180	210	241	263	285	-	-	-	-
17	121	164	206	242	278	304	330	-	-	-	-
18	136	184	233	274	314	344	374	-	-	-	-
19	154	209	264	311	358	392	427	-	-	-	-
20	171	234	296	348	401	440	480	511	542	-	-
21	191	626	332	391	450	496	542	579	616	-	-
22	211	289	357	434	599	552	593	546	581	-	-
23	231	317	494	467	552	608	663	714	766	-	-
24	251	345	441	523	605	664	723	782	840	-	-
25	275	380	484	574	665	732	800	865	930	-	-

Figure 3. A tree volume table based on the International ¼" rule. An estimate the board foot volume of a tree is available at the intersection of the row associated with the dbh in the left column and the column for the correct number of logs. For example, a tree with a dbh of 20 inches and 2 logs is estimated to have 296 board feet.

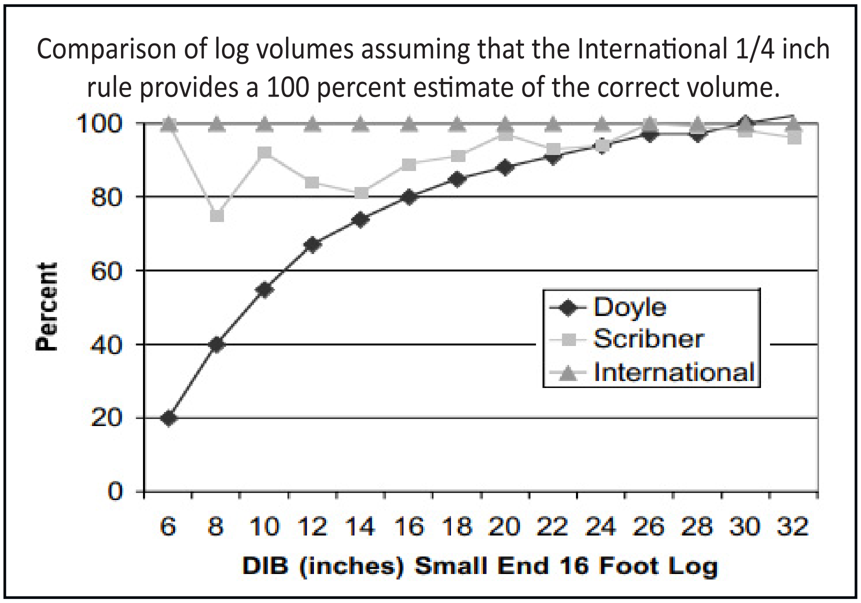

Figure 4. Using yield predicted by the International ¼" rule as a basis, the deviance in volume estimated by Doyle and Scribner are apparent. The rules diverge for the smaller tree diameters, and converge when the small end diameter of the logs is between 22 and 32 inches. [Figure adapted from Figure 1, page 4, of D. Cassens, Log and Tree Scaling, Purdue University Cooperative Extension FNR-191.]

The risk with differences among the rules is both perceived and real. As an owner, it seems unjust to be told that a tree has an estimated volume that is significantly smaller than the actual volume. Any claim of a tree's volume is an estimate based on assumptions, as described above, and might be inaccurate but isn't unjust. How that estimate is used may be unjust. There is also concern by woodland owners that when they sell timber, their timber volume will be underestimated. Finally, one buyer of logs might offer to pay a certain price per board foot, and a different buyer will offer a different price per board foot, but use a different log rule. There are two ways to resolve these concerns. First, if you are scaling logs or trees either have the scaler use a particular rule, or obtain the original measurements and recalculate the volumes using the desired rule. Second, when selling timber, it is best to arrange your harvest such that all contractual discussions about the trees for sale are stated in terms of dollars rather than board feet. Sale arrangements that involve percentage or per board foot can become messy. Sale arrangements in total dollar value avoid these problems.

Reference

Cassens, D. 2001. Log and tree scaling techniques. Purdue University, Forestry and Natural Resources, Cooperative Extension Service. Publication FNR-191. www.extension.purdue.edu/extmedia/fnr/fnr-191.pdf

For additional information on woodland management go to:
www.ForestConnect.com & www.CornellForestConnect.ning.com

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