# University of Missouri Extension

G5050, Reviewed October 1993

# How to Measure Trees and Logs

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Selling timber without measuring the products is like selling livestock without weighing the animals. Knowing what you have to sell and securing several bids can mean many additional dollars from your timber sales. With the assistance of a professional forester, decide which trees are ready for market, then measure them and mark them with paint spots at breast height and below stump height. If the trees are already cut, scale the logs before they are sent to the mill.

The Missouri Department of Conservation will furnish a cruising stick to any Missouri landowner free of charge. The cruising stick is a Biltmore Stick on one side and a log scaling stick on the other side. You can obtain one from your local Missouri Department of Conservation district forestry office. Your cruising stick, plus the volume tables in this publication, will enable you to compute the volume in either standing trees or logs.

Before logs or trees can be bought or sold, it is necessary to determine their content by some standard. The board foot is the most common standard used for saw logs and lumber. A board foot contains 144 cubic inches of sawed lumber or the equivalent of a board 1 inch thick, 12 inches wide and 1 foot long.

A second unit of measure is the cord. Fuel wood and pulp wood (wood used to make paper) are measured and sold by the cord. The standard cord is a pile of wood 4 feet high, 4 feet wide and 8 feet long. It occupies 128 cubic feet of space, but does not actually contain 128 cubic feet of wood because of the air spaces.

Fuel wood and pulp wood are often cut in various lengths. A pile 5 feet wide, 4 feet high and 8 feet long occupies 160 cubic feet and is called a "long cord." Similarly, a pile of wood 4 feet high and 8 feet long cut into 1- or 2-foot lengths is a "short cord," which occupies less than 128 cubic feet.

The following formula may be used to determine the number of standard cords in a stack of wood:

$$\text{Number of standard cords} = \frac{\text{[length (feet) x width (feet) x height (feet)]}}{128}$$

**Example**

Take a stack of wood that is 10 feet long, 6 feet wide and 3 feet high. Substituting these figures into the formula we get:

$$\text{Number of cords} = \frac{(10 \times 6 \times 3)}{128} \quad \frac{180}{128} = 1.406 \text{ cords}$$

A third unit of measure is the "cubic foot." In the United States, the cubic foot unit of measure is used chiefly in growth and yield studies or in forest inventory and research projects, but generally not in commercial dealings. It represents a block or cube of wood 1 foot high, 1 foot wide and 1 foot thick.

Another unit of measure commonly found in Missouri is the "chord foot," which is used to measure cooperage bolts. This unit is based on the length of line along the chord of the bolt. A "chord foot" is 12 inches measured along the chord, inside the bark, from "sapwood to sapwood," or from "heartwood to heartwood." Prices per chord foot depend primarily upon the quality and amount of heartwood (redwood) in the bolt and also upon the length of the bolt.

Cooperage bolts vary in length, but "stave" bolts are most commonly 39 inches long with "heading" bolts 24 inches in

length. Estimated chord foot yields from sound trees are shown in Table 1.

**Table 1**
Stave bolt and heading volumes in standing trees

| Stave bolts | Number of 39-inch cuts | | | | | | |
|---|---|---|---|---|---|---|---|
| Diameter Breast Height, D.B.H. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Volume in chord feet | | | | | | |
| 12 inches | 1.6 | 3.0 | | | | | |
| 14 inches | 2.8 | 5.4 | 7.0 | | | | |
| 16 inches | 3.3 | 6.3 | 8.4 | 10.0 | | | |
| 18 inches | 3.9 | 7.4 | 10.7 | 13.7 | 16.5 | 19.1 | |
| 20 inches | 4.2 | 8.2 | 12. | 15.6 | 18.9 | 21.9 | 24.7 |
| 22 inches | 4.9 | 9.4 | 13.6 | 17.6 | 21.5 | 25.0 | 28.3 |
| 24 inches | 5.2 | 10.2 | 15.1 | 19.6 | 23.8 | 27.8 | 31.7 |
| 26 inches | 6.0 | 11.6 | 16.8 | 21.8 | 26.7 | 31.2 | 35.4 |
| 28 inches | 6.5 | 12.7 | 18.7 | 24.3 | 29.5 | 34.5 | 39.4 |
| 30 inches | 9.3 | 16.0 | 22.5 | 28.7 | 34.7 | 40.3 | 45.2 |
| 32 inches | 11.5 | 21.9 | 31.2 | 37.9 | 44.4 | 50.6 | 56.6 |
| 34 inches | 12.2 | 24.1 | 35.6 | 46.0 | 55.3 | 62.0 | 68.5 |
| 36 inches | 14.1 | 27.2 | 39.4 | 51.3 | 62.8 | 73.2 | 82.5 |

| Heading bolts | Number of 24-inch cuts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| D.B.H. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | Volume in chord feet | | | | | | | | | |
| 18 inches | 4.6 | 9.2 | 13.7 | 18.1 | 22.3 | | | | | |
| 20 inches | 5.1 | 10.2 | 15.2 | 20.1 | 24.9 | 29.5 | 34.0 | 38.4 | 42.7 | |
| 22 inches | 5.6 | 11.2 | 16.7 | 22.1 | 27.3 | 32.4 | 37.3 | 42.0 | 46.5 | 50.7 |
| 24 inches | 6.1 | 12.0 | 17.6 | 22.9 | 27.9 | 32.6 | 37.0 | 41.0 | 44.9 | 48.5 |
| 26 inches | 6.7 | 13.1 | 19.2 | 25.0 | 30.5 | 35.7 | 40.6 | 45.2 | 49. | 53.0 |
| 28 inches | 7.2 | 14.1 | 20.7 | 27.0 | 33.0 | 38.7 | 44.1 | 49.2 | 54.0 | 58.5 |
| 30 inches | 7.7 | 15.1 | 22.2 | 29.0 | 35.5 | 41.7 | 47.6 | 53.2 | 58.5 | 63.5 |
| 32 inches | 8.2 | 16. | 23.7 | 31.0 | 38.0 | 44.7 | 51.1 | 57.2 | 63.0 | 68.5 |

**Data from MU AGR. EX. SVC. CIR 671 and EX. SVC. Kansas State University, 3A-574-4-500**

# Volume content of logs and standing trees

The volume of wood in standing trees may be estimated by obtaining two measurements and applying these to tree scale volume tables. The two measurements are diameter and merchantable height.

Once the techniques for determining tree diameter and height have been mastered, it becomes relatively easy to determine tree volume. For standing trees, this can be accomplished by checking a tree volume table (Table 2), which is simply a tabulation of volumes of trees corresponding to different tree heights and diameters.

Measuring the board-foot content of a log or a group of logs is known as log scaling. The only equipment needed to scale logs is a yardstick and a log rule (Table 3). To speed up "scaling," a log scaler uses a scaling stick. A scaling stick serves as a yardstick and has printed on it a log rule from which the contents of a log can be read as it is measured.

When calculating the volumes of standing trees, landowners should be sure they are reading from a tree volume table and when measuring logs that their volumes are from a log rule. A comparison of Tables 2 and 3 will show why this is important.

Another factor to know is the difference between various log rules. Because of certain factors, there are variations in sawed output of logs. These factors have resulted in the development of more than 50 log rules in the U.S. The International 1/4-inch Log Rule (Table 3) and the Doyle Log Rule (Table 4) are the two most commonly used rules in Missouri. The International Rule takes into account the taper in a log and probably is the most accurate, but it requires the sawmill to have a good sawyer and good equipment to cut out the volumes estimated.

**Table 2**

Board-foot volume of trees[1] by diameter and height classes (International Rule — Form Class 76)

| D.B.H. | Number of 16-foot logs in trees | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1/2 | 1 | 1-1/2 | 2 | 2-1/2 | 3 | 3-1/2 |
| | Volume in board feet | | | | | | |
| 10 inches | 21 | 34 | 44 | 55 | | | |
| 12 inches | 30 | 52 | 68 | 85 | 98 | | |
| 14 inches | 42 | 74 | 99 | 124 | 143 | 162 | |
| 16 inches | 59 | 100 | 134 | 169 | 198 | 226 | 246 |
| 18 inches | 74 | 129 | 175 | 221 | 259 | 297 | 325 |
| 20 inches | 92 | 162 | 220 | 279 | 328 | 377 | 413 |
| 22 inches | 112 | 198 | 271 | 344 | 406 | 467 | 514 |
| 24 inches | 133 | 237 | 326 | 415 | 491 | 567 | 622 |
| 26 inches | 158 | 284 | 392 | 500 | 592 | 684 | 755 |
| 28 inches | 187 | 331 | 458 | 585 | 696 | 806 | 888 |
| 30 inches | 220 | 381 | 529 | 677 | 805 | 933 | 1029 |
| 32 inches | 254 | 435 | 606 | 776 | 926 | 1077 | 1192 |
| 34 inches | 291 | 493 | 687 | 881 | 1054 | 1227 | 1359 |
| 36 inches | 333 | 559 | 782 | 1006 | 1205 | 1404 | 1557 |
| 38 inches | 374 | 624 | 874 | 1125 | 1354 | 1582 | 1754 |
| 40 inches | 415 | 693 | 974 | 1256 | 1510 | 1764 | 1962 |

**[1]For estimating board feet in standing trees**

**Table 3**

The board-foot contents of logs according to the International Rule using a saw cutting 1/4-inch kerf

| Diameter of log small ends, inside bark | Length of logs (feet) | | | | |
| --- | --- | --- | --- | --- | --- |
| | 8 | 10 | 12 | 14 | 16 |
| | Board feet | | | | |
| 6 inches | 10 | 10 | 15 | 15 | 20 |
| 7 inches | 10 | 15 | 20 | 25 | 30 |
| 8 inches | 15 | 20 | 25 | 35 | 40 |
| 9 inches | 20 | 30 | 35 | 45 | 50 |
| 10 inches | 30 | 35 | 45 | 55 | 65 |
| 11 inches | 35 | 45 | 55 | 70 | 80 |
| 12 inches | 45 | 55 | 70 | 85 | 95 |
| 13 inches | 55 | 70 | 85 | 100 | 115 |
| 14 inches | 65 | 80 | 100 | 115 | 135 |
| 15 inches | 75 | 95 | 115 | 135 | 160 |
| 16 inches | 85 | 110 | 130 | 155 | 180 |
| 17 inches | 95 | 125 | 150 | 180 | 205 |
| 18 inches | 110 | 140 | 170 | 200 | 230 |
| 19 inches | 125 | 155 | 190 | 225 | 260 |
| 20 inches | 135 | 175 | 210 | 250 | 290 |
| 21 inches | 155 | 195 | 235 | 280 | 320 |
| 22 inches | 170 | 215 | 260 | 305 | 355 |
| 23 inches | 185 | 235 | 285 | 335 | 390 |
| 24 inches | 205 | 255 | 310 | 370 | 425 |
| 25 inches | 220 | 280 | 340 | 400 | 460 |
| 26 inches | 240 | 305 | 370 | 435 | 500 |
| 27 inches | 260 | 330 | 400 | 470 | 540 |
| 28 inches | 280 | 365 | 430 | 505 | 585 |
| 29 inches | 305 | 385 | 465 | 545 | 630 |
| 30 inches | 25 | 410 | 495 | 585 | 675 |

**Table 4**
The board-foot contents of logs according to the Doyle Log Scale

| Diameter | Length of log (feet) | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | 6 | 8 | 10 | 12 | 14 | 16 |
| | Contents in board feet | | | | | |
| 8 inches | 6 | 8 | 10 | 12 | 14 | 16 |

| 9 inches | 9 | 13 | 16 | 19 | 22 | 25 |
|---|---|---|---|---|---|---|
| 10 inches | 14 | 18 | 23 | 27 | 32 | 6 |
| 11 inches | 18 | 25 | 31 | 37 | 43 | 49 |
| 12 inches | 24 | 32 | 40 | 48 | 56 | 64 |
| 13 inches | 30 | 41 | 51 | 61 | 71 | 81 |
| 14 inches | 38 | 50 | 63 | 75 | 88 | 100 |
| 15 inches | 45 | 61 | 76 | 91 | 106 | 121 |
| 16 inches | 54 | 72 | 90 | 108 | 126 | 144 |
| 17 inches | 63 | 85 | 106 | 127 | 148 | 169 |
| 18 inches | 74 | 98 | 123 | 147 | 172 | 196 |
| 19 inches | 84 | 113 | 141 | 169 | 197 | 225 |
| 20 inches | 96 | 128 | 160 | 192 | 224 | 256 |
| 21 inches | 108 | 145 | 181 | 217 | 253 | 289 |
| 22 inches | 122 | 162 | 203 | 243 | 284 | 324 |
| 23 inches | 135 | 181 | 226 | 271 | 316 | 361 |
| 24 inches | 150 | 200 | 250 | 300 | 350 | 400 |
| 25 inches | 165 | 221 | 276 | 331 | 386 | 441 |
| 26 inches | 182 | 242 | 303 | 363 | 424 | 484 |
| 27 inches | 198 | 265 | 331 | 397 | 463 | 529 |
| 28 inches | 216 | 288 | 360 | 432 | 504 | 576 |
| 29 inches | 234 | 313 | 391 | 469 | 547 | 625 |
| 30 inches | 254 | 338 | 423 | 507 | 592 | 676 |

# Scaling logs

The scaling of logs is the normal basis for transactions between loggers and sawmillers. Although not as accurate as the actual lumber tally after sawing, log scaling has certain advantages. It permits prompt settlement for timber cut and delivered without waiting for actual yield, and it eliminates the need for separating logs on the yard by ownership.

Scaling practices may vary in local areas. Therefore, these practices should be agreed upon before sawlogs are sold. The standard methods for obtaining log measurements are:

**Diameter**
measured at the small end, inside the bark and to the nearest inch. For logs that are not round, average diameters should be taken. For example, a log measuring 10.0 inches in one direction across the diameter and 11.2 inches in another direction will average 10.6 inches. This would be scaled as an 11-inch log.

**Length**
usually measured to an even number of feet such as 8, 10, 12, etc. If logs are cut to lengths between these even numbers, then the length is called to the smaller even number rather than to the nearest even number. For example, a log measuring 15 feet, 7 inches would be scaled as a 14-foot log rather than as a 16-foot log. In actual practice, about 3 inches additional length should be allowed. This will permit trimming the rough ends of boards sawed from the log.

Once the diameter and length have been measured, the log rule is used to determine the board-foot volume. Since log rules are constructed on the basis of sound, straight logs and no allowance is made for defect, volume loss due to defect must be calculated separately and deducted from the gross scale given by the log rule. There are guides available for estimating the amount of defect in logs.

# Measuring standing timber

Timber is often sold on a stumpage basis, which means it is sold in standing trees rather than cut products such as logs, posts and pulp wood. To determine the volume of a tree, its d.b.h. (diameter breast height) and merchantable height must be determined. When these two measurements are known, the volume of the tree can be read directly from a tree volume table.

# Measuring diameter at breast height (d.b.h.)

Diameter measurements of standing timber are made at breast height, which is 4-1/2 feet above the ground, because this is above the swell of the base of most trees.

The two most frequently used instruments to measure tree diameter are the diameter tape and the cruising stick. The diameter tape shows tree diameter by measuring circumference. It is based on the fact that circumference of a circle is equal to the circle's diameter multiplied by 3.14. Consequently, each division on the tape is 3.14 inches apart, with each division representing 1 inch in the tree's diameter. The diameter tape is wrapped around the tree at breast height and the diameter is read directly from the tape.

The cruising stick does not measure as accurately as the diameter tape but is much faster. It is based on a system of similar triangles (identical angles but different side lengths) to determine the distances on the stick that correspond to each inch in diameter.

To use the cruising stick, hold it horizontally, 25 inches from your eye (about arm's reach for the average person) against the tree at breast height. Be sure you have the "diameter measurement" side (front) of the stick toward you and not the log scaling side (back). Line up the zero end with the outside of the tree. Then without moving your head and using only one eye, look at the other side of the tree and read the figure nearest to where your line of sight crossed the stick and the edge of the tree. That number is the estimate of the tree's diameter at breast height.

It is important to move your eye instead of your head, or your reading will not be correct

If the tree is not round, take another reading at a right angle to the first and average the two readings.

# Measuring merchantable (usable) height

Individual tree height normally is measured from a 6-inch stump to a point on the stem beyond which marketable sawlogs or other products cannot be cut. For sawlogs (a 16-foot log), the merchantable height usually is to a top diameter of not less than 8 inches. Cordwood (short logs, called "bolts") may be figured to about a 4-inch diameter. It is important to note that the merchantable top may occur at a point lower on the trunk than previously mentioned if merchantability is limited by forking, large branches or deformity.

To measure height, use that portion of the front of your cruising stick marked off as "number of 16-foot logs."

- Starting with your heel at the base of the tree, pace out a distance of 50 feet. Pace toward an opening that will allow you to see the tree you are measuring. Do not pace up or down hill any more than necessary, but try to stay as close to the same level as the base of the tree as possible.
- Decide where the last cut will be made when the tree is cut into logs (merchantable height of the tree).
- Hold the stick 25 inches from your eye (arm's length for the average person) but in a vertical position. Be sure the

side of the stick with the "number of 16-foot logs" is toward you.
- Move the stick up or down until the lower end is even with your line of sight to stump height on the tree.
- Without moving your head, shift your vision upward to the point that you decided was the usable length of the tree. The point where your line of sight passes the stick amounts to a reading in terms of 16-foot logs. Be sure the stick is in a vertical position and not tilted forward or backward. Make your reading to the nearest half-log.

If it is necessary to go farther than 50 feet for a clear view of the tree, you may pace twice the distance and then double the reading obtained from the stick. After a little practice in timber cruising, you will find that you do not need to measure the merchantable heights of all trees. Foresters usually measure a few during a day of cruising just to "check their eye," but most of the height estimating is done by eye rather than by measurement when tallying saw timber.

# Computing the volume of standing trees

- Read down the left-hand column of the tree volume table (Table 2), which is headed "Diameter breast height," and find the diameter of the tree.
- Read across the table to the proper column for the number of 16-foot logs in the tree and find the volume in board feet.
- Remember that the International Rule is very accurate and that sound logs or trees will saw out very close to the number of board feet indicated. However, if a tree or log is too crooked or defective, it will be necessary to reduce the volume accordingly. The quality of the log and the grade of the material it will produce often affect the price you will be offered for it.

# Computing board feet in logs

On the back side of the Missouri Department of Conservation cruising stick is an International Log Rule. To use the rule, read from the stick the number of board feet in a log of the length you have measured. (Log lengths in feet are printed in the left-hand column on the stick and read 8, 10, 12, 14 and 16.) The diameters (in inches) are printed across the top of the stick. The point of intersection of the diameter and log length columns gives the board feet in the log if the log is straight and sound. Defects must be deducted.

# Computing cordwood

Table 5 gives rough estimates of the amount of cordwood that can be produced from trees of various diameters and heights. The table is read in the same manner as the tree volume and log rule tables.

**Table 5**
Cord volume

| D.B.H. | Height in number of 8-foot bolts | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| | Volume in cords — unpeeled | | | | | |
| 6 inches | 0.02 | 0.03 | 0.04 | 0.06 | | |
| 8 inches | 0.03 | 0.05 | 0.07 | 0.09 | 0.12 | 0.14 |
| 10 inches | 0.05 | 0.07 | 0.10 | 0.13 | 0.17 | 0.20 |
| 12 inches | 0.07 | 0.10 | 0.14 | 0.18 | 0.22 | 0.27 |
| 14 inches | 0.10 | 0.13 | 0.18 | 0.23 | 0.29 | 0.35 |
| 16 inches | 0.12 | 0.17 | 0.22 | 0.29 | 0.36 | 0.44 |
| 18 inches | | 0.20 | 0.27 | 0.35 | 0.44 | 0.53 |

| 20 inches | | 0.25 | 0.32 | 0.42 | 0.52 | 0.63 |
|---|---|---|---|---|---|---|

**Taken from Technical Note 202, Lakes States Forest Experiment Station, University Farm, St. Paul, Minnesota, 1943. Volume is stem volume above one foot stump in standard unpeeled cords (standard cord is 4 feet x 4 feet x 8 feet). Height is number of usable 8-foot bolts to a variable top diameter, not less than 4 inches inside the bark.**

# Some woodland management tips

- Eliminate wildfire and excessive grazing from your timber.
- Do not sell good quality trees until they are mature. This usually means 18 inches or more in diameter at breast height.
- Do not sell timber until you know what you are selling in terms of board feet or other unit of measure.
- Draw up a sale contract before you close the deal. Sample contracts are available from your farm forester or MU Extension forester.
- Treat your woodland as any other crop. Manage it to maintain the proper number of good quality trees per acre. See your farm forester or MU Extension specialist for assistance with farm woodland management, or write to the State Forester, Missouri Department of Conservation, Jefferson City, Mo. 65101, or the MU Extension forester, MU, Columbia, Mo. 65201.

### Related MU Extension publications

- G5055, Determining Timber Cost Basis
  http://extension.missouri.edu/p/G5055
- G5452, How to Buy and Sell Cordwood
  http://extension.missouri.edu/p/G5452

Order publications online at http://extension.missouri.edu/explore/shop/ or call toll-free 800-292-0969.