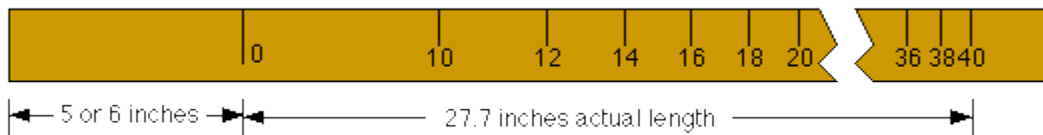


The Biltmore Stick

A Tree Measurement Tool

The Biltmore Stick is an old tool, dating to around the (middle of the 18th century). The concept is simple: a device that can be used easily in the field to measure trunk diameters and heights of standing trees.

The stick looks like the familiar "yard stick." It is (usually) a strip of wood with measurements marked to show the corresponding diameter or height. It differs from the yard stick, though, in that the increments of the measurements decrease as the diameter or height increases.

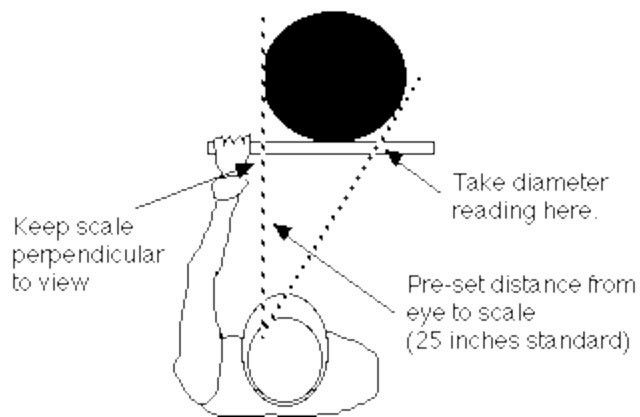


To measure diameter

The stick is held against the tree trunk at arm's length (about 25 inches from the eye—practice to get it the right distance!). The stick should be perpendicular to your arm, and should just touch the trunk. Align the "0" (zero) mark with the edge of the trunk, so it appears they are in line. Without moving your head, look at the far end of the stick, and note where the other side of the trunk crosses the stick. Read the measurement directly from the stick.

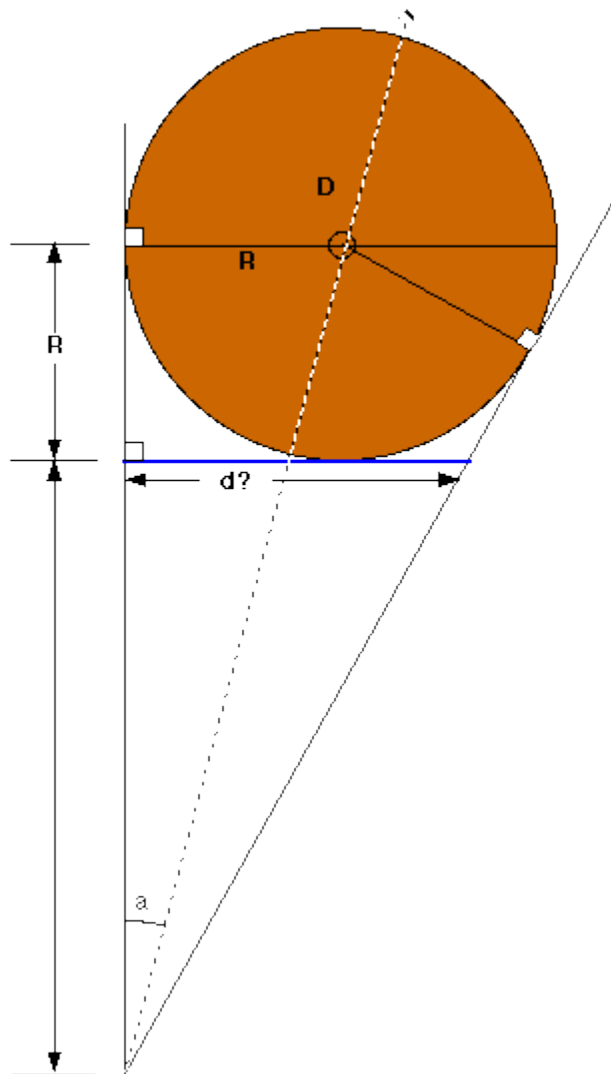
That's all there is! The key is to practice for accuracy and consistency. The points to remember are:

1. Keep the stick perpendicular to your reach.
2. Hold the stick the right distance from your eye (25 inches is standard, but you can customize your stick)
3. Do not move your head when reading the far end (this causes a shift in the intersect with the tree trunk)
4. Accuracy is not guaranteed. Practice helps. The nearest two-inch diameter class is suggested.



How It Works

There is a little math involved in this. Remember your high school trigonometry? A couple of triangles show the process.



Solution:

R is a known variable (tree radius)

$$\tan a = R / (25 + R)$$

$$\tan 2a = d / 25$$

$$d = 25 * \tan (2 * (\tan^{-1} (R / (R + 25))))$$

The stick is represented in the diagram by the *blue* line. As you hold the stick against the tree, your line of sight is perpendicular to the stick at the zero mark, where it lines up with the left side of the tree. When you sight to the right edge of the tree, you read the diameter where the tree appears to intersect the stick. Since the radius is not in a direct line, an adjustment must be made. Otherwise the reading would be much too high (the point on the tree diameter where the lines intersect out beyond the trunk).

For a given tree diameter we know the radius (**R**). We also know distance to the tree from the apex (eye) is a set distance. For this example, we'll use 25 inches, the standard distance. The length from the eye to the center of the tree is (**R + 25**). From this, we calculate the angle (**a**). Since the two main triangles are the same, we know that the tangent of twice the angle (**a**) is the stick measurement divided by the distance from the eye to the stick (**tan 2a = d / 25**). Now we just substitute the value of twice the angle (**a**) into the formula and solve for (**d**).

$$d = 25 * \tan (2 * (\arctan [R / (R + 25)]))$$

You can sit down with the old trig tables and some paper to figure this out, or you can have your computer do it for you. A spreadsheet applications does it quite neatly. You can also adjust the distance for your customized stick to your reach. If you have long arms, maybe 26 or 27 inches will be more comfortable. Just change that parameter in the formula.

The chart below contains the stick measurements. Measure the Stick distance along the Biltmore stick, and mark it clearly. Continue for the length of the stick. Be sure to clearly mark the tree diameter that corresponds to each measurement. When you are finished, coat the entire stick with a clear finish such as polyurethane, for durability. Note that the chart is in *inches*, and is for a *25-inch reach*.

Tree	Stick	Tree	Stick
10	8.6	30	21.8
11	9.3	31	22.4
12	10.1	32	23
13	10.8	33	23.6
14	11.5	34	24.2
15	12.2	35	24.8
16	12.9	36	25.4
17	13.6	37	26
18	14.2	38	26.5
19	14.9	39	27.1
20	15.6	40	27.7
21	16.2	41	28.3
22	16.9	42	28.8

23	17.5	43	29.4
24	18.1	44	30
25	18.8	45	30.5
26	19.4	46	31.1
27	20	47	31.7
28	20.6	48	32.2
29	21.2		

Height Measurements

You can easily add height measurements to your stick, making it easy to estimate tree height. The formula for this is very easy. Use the same "reach," or distance from eye to stick. You will also need to know the distance from you are standing from the tree. A distance of 100 feet is suggested as a base. Some sticks have scales for 100 and for 66 feet (one chain).

To determine the height of the tree (or other object) hold the stick vertically at your normal reach. Align the zero point with the bottom of the tree stump. Read the height at the point where the top of the tree appears to intersect the stick.

The formula is easier for this part. To calculate the measurement on the stick (**S**) at a base distance of 100 feet:

$$S = 25 * (H / 100)$$

For a base of 66 feet:

$$S = 25 * (H / 66)$$

As with the other formula, if you have a reach that is greater or less than 25 inches, you can vary the formula accordingly. Now simply measure your stick, and mark it. Be sure to label the scales as 100 foot base or 66 foot base.

As a final feature on your stick, mark off standard inches. This can be a great help in measuring cut stumps, logs, etc. You don't need to put all the scales on one side- there are several sides and even the edges you can use. Drill a hole in one end of the stick, and attach a leather or nylon thong as a wrist strap. And remember to finish with a clear coat.