MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND
COLLEGE PARK•EASTERN SHORE

Fact Sheet

Fact Sheet 629

Woodland Management

Measuring Your Forests

As a landowner, you may need to measure property boundaries, ground slope, standing timber size, and log volume. Although forests and forest products are measured most efficiently and precisely with sophisticated—and often expensive—instruments, you can make most necessary measurements with a few simple and inexpensive tools. This fact sheet discusses a number of these instruments.

There are many tricks and pitfalls with each of these tools; more than can be described in this publication. We recommend hands-on instruction from a forester or other knowledgeable person. Otherwise, purchase one of the references listed at the end of this publication for more details on measuring techniques.

Figure 1. To use an abney level, sight an object through the telescope and move the level bubble to the center position. The number on the scale is the correct reading.

Measurement Tools

Abney Hand Level

This delicate instrument consists of a sighting tube and a level bubble with attached scales. The scales usually graduate in degrees or percentages. The abney hand level measures vertical angles and is useful for determining ground slope, road grade, and tree height. Approximate cost is $120 to $140 (Figures 1 and 2).

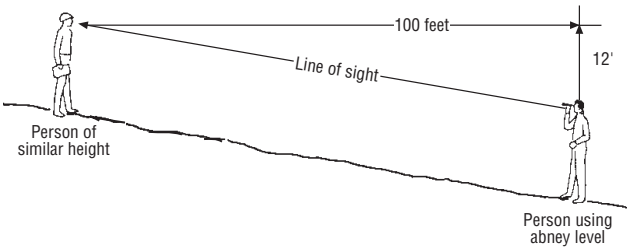


Figure 2. Measuring the slope of a hill with an abney level or clinometer. (The reading is +12 on a percent scale.) Both people are the same height so the lower person can sight at the eyes of the upper person. The distance between individuals is not crucial to making this measurement. (Figure courtesy of Oregon State University CES.)

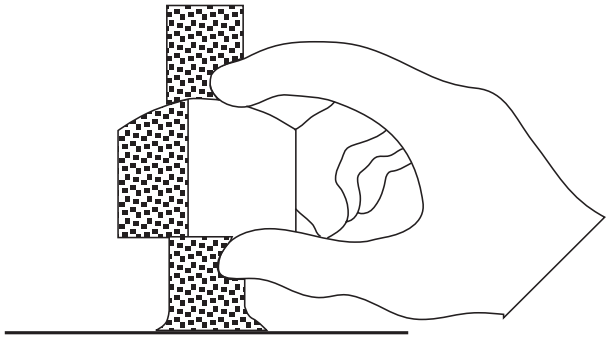


Figure 3. A wedge prism—one of the angle gauges available for estimating the basal area of a stand of trees. (Figure courtesy of Oregon State University CES.)

Angle Gauge

Angle gauges are mechanical or optical devices used to select trees during variable plot sampling. The most common angle gauge is a wedge prism: a precisely ground glass wedge that is calibrated in basal area factors (BAF). You need different BAF prisms for different diameter classes of timber. Special training is needed to use this device properly (Figure 3).

Biltmore Stick

The Biltmore Stick is one of several devices for making simple but crude estimates of tree height and diameter. You can purchase or make one easily. A tree scale stick is just as useful and much cheaper than a Biltmore Stick. Approximate cost for the Biltmore Stick is $35 to $40 (Figures 4 and 5).

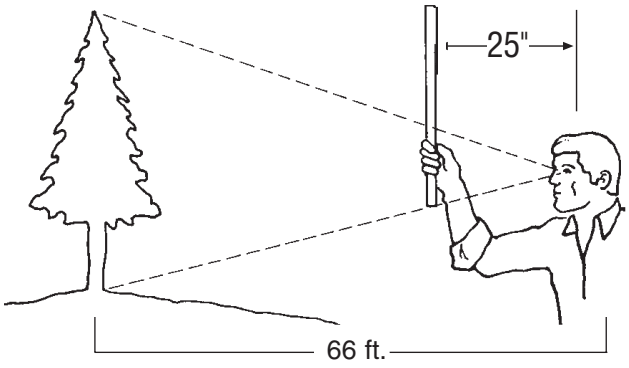


Figure 4. Measuring tree height with a Biltmore or tree scale stick. Pace or measure 66 feet from the tree to be measured. Most sticks are made to be held 25 inches from the eye—any other distance causes incorrect readings. (Figure courtesy of Oregon State University CES.)

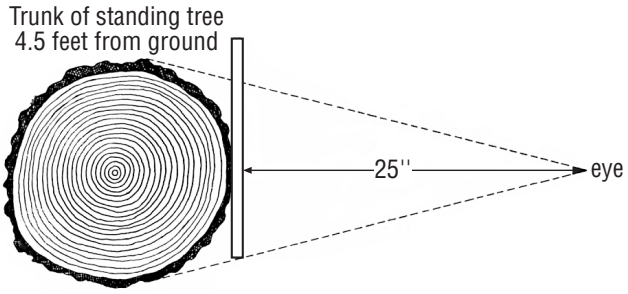


Figure 5. Measuring tree diameter with a Biltmore or tree scale stick. (Figure courtesy of Oregon State University CES.)

Clinometer

This is a rugged, hand-held instrument commonly used for measuring vertical angles. The most useful model is one that has both topographic and percent scales, which allow direct reading of height at a distance of 66 feet and 100 feet from the tree, respectively. Approximate cost is $90 to $100 (Figures 6, 7, and 8).

Figure 6. The clinometer has a sighting hole and a suspended circular scale.

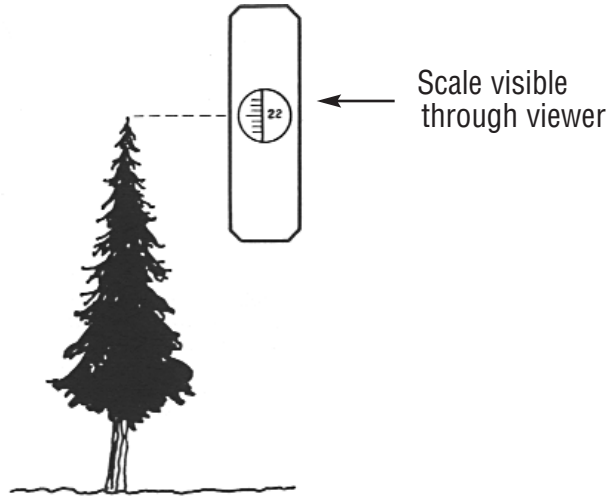


Figure 7. Viewing a tree top with a clinometer. (View the tree with the left eye and read the clinometer scale with the right eye.)

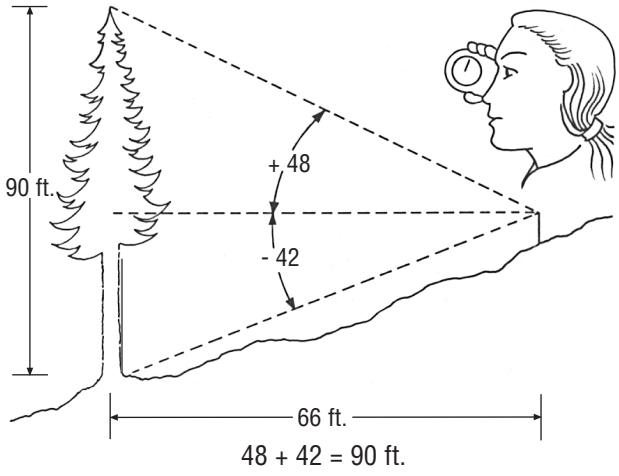


Figure 8. Estimating tree height with a clinometer at a distance of 66 feet from the tree using the topographic scale. A similar estimate would be found by measuring the height at 100 feet from the tree using the percent scale on the clinometer. (Figure courtesy of Oregon State University CES.)

Compass

A hand-held compass is a relatively rugged instrument that measures horizontal angles or direction. Liquid-filled, transparent-base compasses are preferred for all-around use. For the most precise reading, place the compass on a solid, nonferrous object. Approximate cost is $20 to $40 (Figure 9).

Diameter Tape

The diameter tape is a steel tape used to measure tree circumferences. It is calibrated to

Figure 9. High precision hand compass with reflective mirror for field work.

Figure 10. Measuring tree diameter at 4.5 feet from the ground using a diameter tape calibrated to allow direct tree diameter readings in inches.

Figure 11. Increment borer with core sample from tree.

permit direct tree diameter readings. Approximate cost is $25 to $50 (Figure 10).

Increment Borer

This hand-operated drill has a hollow bit used to extract a wood core from the stem of a tree. Borers vary in length, but the maximum sampling depth is approximately 16 inches. This depth is adequate for determining the age of trees up to 30 inches in diameter (including bark). The wood core also provides a record of a tree's diameter growth in previous years. Approximate cost is $135 to $180 (Figure 11).

Increment Hammer

This specialized hammerlike tool has a hollow bit that you drive into the tree. The short core sample—limited to the outer inch of the tree—provides a quick record of recent growth. Approximate cost is $65 to $90 (Figure 12).

Log Volume Table

This table lists volumes by length and small-end diameter for logs on the ground. Tables come in board-foot and cubic-foot log measurements and are available from supply companies and professional foresters (Table 1). Log tables based on the International 1/4-inch log rule are the most common and are more accurate than tables based on the other commonly used log rule, the Doyle log rule. The Doyle log rule is often used by loggers and sawmills and will underestimate volume in logs with diameters less than 28 inches.

Table 1. Doyle and International Log Rules for Scaling Board-Foot Content.

Diameter inside bark, small end (inches)	Length of Log (feet)									
	Doyle					International				
	8	10	12	14	16	8	10	12	14	16
6	—	—	—	—	—	10	10	15	15	20
7	—	—	—	—	—	10	15	20	25	30
8	8	10	12	14	16	15	20	25	35	40
9	13	16	19	22	25	20	30	35	45	50
10	18	23	27	32	36	30	35	45	55	65
11	25	31	37	43	49	35	45	55	70	80
12	32	40	48	56	64	45	55	70	85	95
13	41	51	61	71	81	55	70	85	100	115
14	50	63	75	88	100	65	80	100	115	135
15	61	76	91	106	121	75	95	115	135	160
16	72	90	108	126	144	85	110	130	155	180
17	85	106	127	148	169	95	125	150	180	205
18	98	123	147	172	196	110	140	170	200	230
19	113	141	169	197	225	125	155	190	225	260
20	128	160	192	224	256	135	175	210	250	290
21	145	181	217	253	289	155	195	235	280	320
22	162	203	243	284	324	170	215	260	305	355
23	181	226	271	316	361	185	235	285	335	390
24	200	250	300	350	400	205	255	310	370	425
25	221	276	331	386	441	220	280	340	400	460

Source: *Essentials of Forestry Practice* by Stoddard & Stoddard. Copyright 1987. Reprinted by permission of John Wiley & Sons, Inc.

Figure 12. An increment hammer is used to obtain a sample of a tree's outer inch.

Logger's Tape

Logger's tape is a retractable steel tape used to measure linear distance. It is made to resist rust, wear, and stretching. The most convenient tapes for forestry use are those that are 50 or 75 feet long. Logger's tape has a belt hook and rewinds automatically when not in use. It is available with a diameter tape on the reverse side. Approximate cost is $50 to $75.

Measuring Tape

Measuring tapes are useful for accurately measuring long distances for boundary and other survey work. Steel tapes are used for precise survey work. However, fiberglass tapes are best for most applications and are accurate, light, strong, flexible, and affordable. Fiberglass tapes come on their own windup reel in lengths of 50 to 300 meters. Approximate cost is $18 to $80.

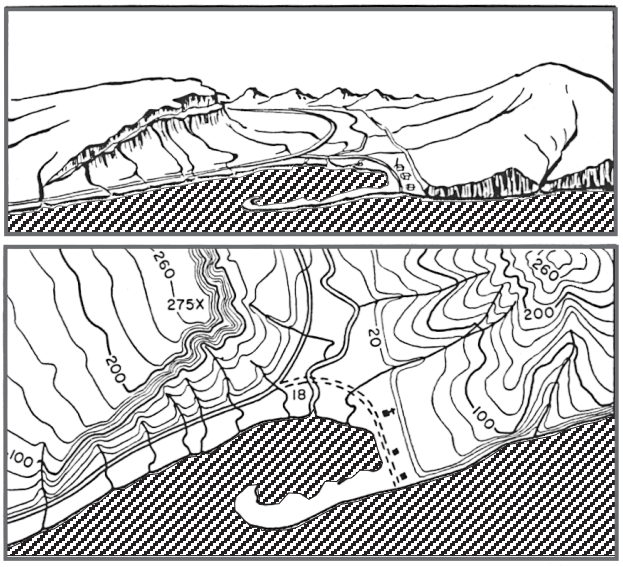


Figure 13. How relief, hydrographic, and cultural features are shown on a topographic map. Above, a perspective view of a river valley that lies between two hills. In the foreground is the sea with a bay partly enclosed by a hooked sandbar. On each side of the valley are terraces through which streams have cut gullies. The hill on the right has a gradual slope with rounded forms, while the hill on the left rises abruptly and ends in a sharp precipice from which it slopes gradually away, forming an inclined tableland that is traversed by a few shallow gullies. Below, a topographic map of the same area with the ground forms represented by contour lines. The contour interval used here is 20 feet, which means that the vertical distance between one contour and the next is 20 feet. (Redrawn from U.S. Geological Survey.) Source: *Essentials of Forestry Practice* by Stoddard & Stoddard. Copyright 1987. Reprinted by permission of John Wiley & Sons, Inc.

Pacing

Pacing is a method rather than a tool, but it is commonly substituted for tools when horizontal distance measurements do not need to be precise. One pace is equal to two steps. Individuals usually calibrate common distance measures to their respective pace. See Woodland Management Series Fact Sheet 619, "How to Determine Your Property Boundaries," for information on estimating your pace.

Topographic Map

Topographic maps use contour lines to show the elevation and position of terrain features, such as ridges, draws, and flat areas. Widely spaced contour lines indicate flat or gentle ground; closely spaced lines indicate

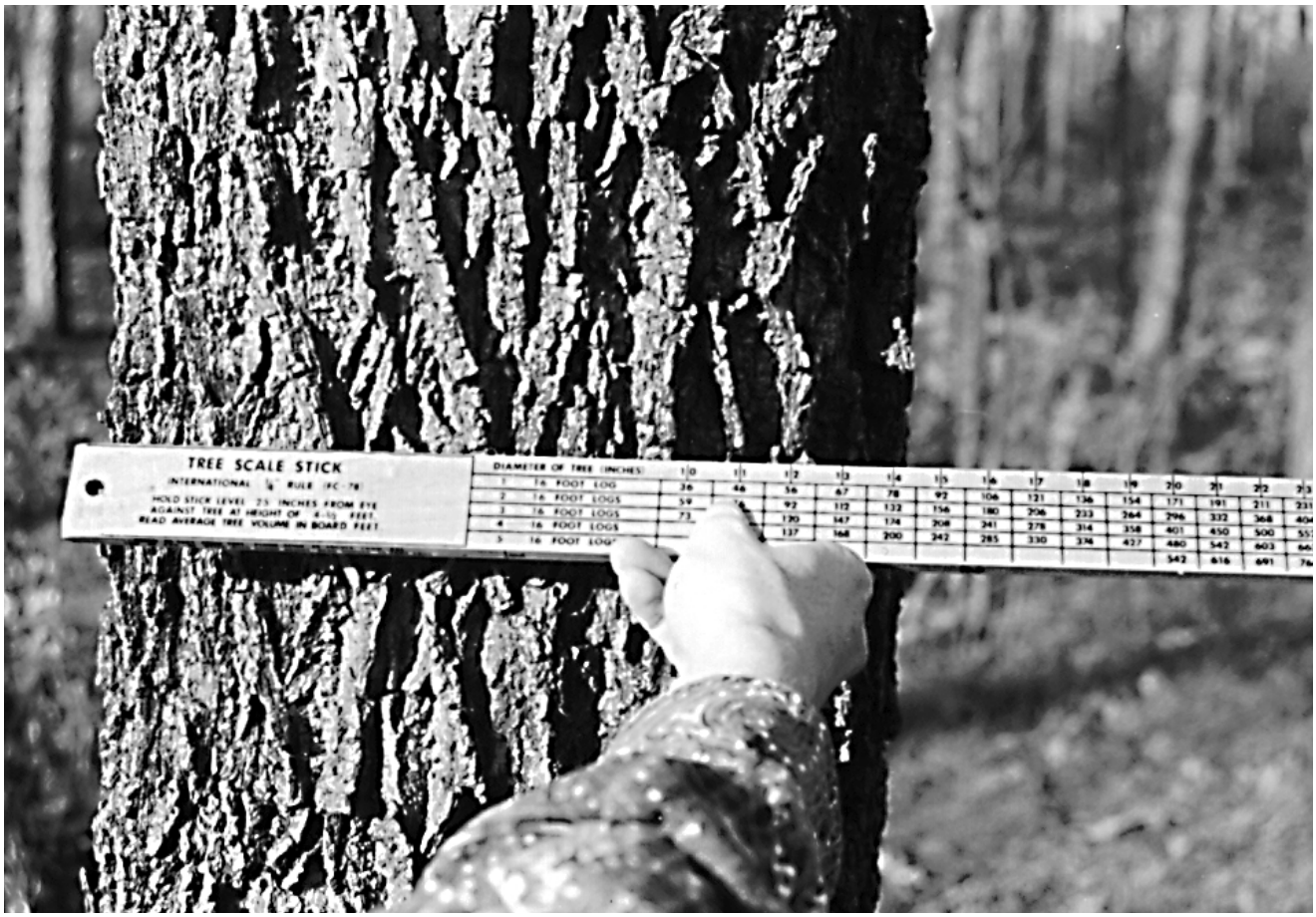


Figure 14. Measuring tree diameter using tree scale stick.

Table 2a. Tree Volume Table Commonly Used to Estimate Board Feet Per Tree.

dbh	*Height in Number of 16-Foot Logs*									
(in.)	½	1	1½	2	2½	3	3½	4	4½	5
	Board Feet Volume/International 1/4-inch Rule									
10	17	39	53	68						
12	30	57	80	100	115					
14	42	79	110	140	163	181	205			
16	59	105	147	180	213	247	278	309		
18	74	135	188	235	278	320	360	400	445	490
20	92	170	236	295	350	402	450	499	552	605
22	112	209	290	362	430	494	555	613	676	704
24	133	252	346	431	512	594	665	742	821	900
26	158	300	409	508	604	698	786	880	980	1080
28	187	348	478	597	705	812	918	1025	1137	1250
30	220	408	552	687	811	934	1061	1180	1315	1450
32	256	471	643	794	935	1077	1216	1358	1519	1680
34	292	534	730	900	1060	1222	1380	1538	1724	1910

Note: Utilization standards: Stump height is 1 foot. Height is number of usable logs to a variable top diameter not smaller than 8 inches inside bark. For tables 2a and 2b, dbh is diameter at breast height measured 4½ feet from the ground. Source: U.S. Forest Service, North Central Forest Experiment Station.

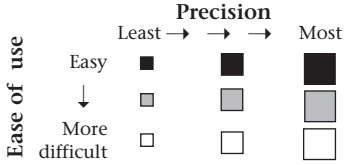
Table 2b. Tree Volume Table Commonly Used to Estimate Cords Per Tree.

dbh	*Height in Number of 8-Foot Bolts*							
(in.)	1	2	3	4	5	6	7	8
	Volume in Cords/Tree							
6	0.02	0.03	0.04	0.06				
8	0.03	0.05	0.07	0.09	0.12	0.14		
10	0.05	0.07	0.10	0.13	0.17	0.20	0.24	0.27
12	0.07	0.10	0.14	0.18	0.22	0.27	0.32	0.36
14	0.10	0.13	0.18	0.23	0.29	0.35	0.42	0.47
16	0.12	0.17	0.22	0.29	0.36	0.44	0.52	0.59
18	0.15	0.20	0.27	0.35	0.44	0.53	0.63	0.72
20	0.18	0.25	0.32	0.42	0.52	0.63	0.76	0.85
22	0.22	0.29	0.38	0.49	0.61	0.74	0.88	1.00

Note: Utilization standards: Volume is stem volume above 1-foot stump in standard, unpeeled cords. The standard cord is 4 x 4 x 8 feet. Height is number of 8-foot bolts to a variable top diameter not less than 4 inches inside bark. Applicable to all species except cedar. Source: U.S. Forest Service, North Central Forest Experiment Station.

Table 3. Precision and Convenience of Measuring Tools.

Item to be measured	Abney hand level	Angle gauge	Biltmore Stick	Clinometer	Compass	Diameter tape	Increment borer	Increment hammer	Log volume table	Logger's tape	Measuring tape	Pacing	Topographic map	Tree & log scale stick	Tree volume table
Boundaries															
Horizontal angles					■										
Horizontal distance										■	■	■			
Road grade	▢			■									▫		
Ground slope	▢			■									■		
Log															
Diameter			▢			□				▢				▢	
Length										■					
Volume									■					■	
Tree															
Age							▢								
Basal area		▢				□									
Current growth							▢	■							
Diameter			■			▢								■	
Height	▢		▫	■										■	
Distance										▢		■			
Vertical angle	▢			■											
Volume														▫	■



steep ground. Ground slopes can be measured from topographic maps (Figure 13).

Tree and Log Scale Stick

This device allows you to estimate standing tree height and diameter (as with a Biltmore Stick), as well as log volume from log diameter and length. Measurements are maximum potential volume before deductions for defects. Approximate cost is $11 (Figures 4, 5, and 14).

Tree Volume Table

Tree volume tables list the wood volume of standing trees in board feet, cubic feet, or both. Tables are based on the height of the entire tree or a specified portion, such as total stem, stem to a 4-inch minimum top diameter, stem to a 6-inch minimum top diameter, etc., and diameter at breast height.

Volume tables based on the International 1/4-inch log rule provide the most accurate estimate of board-foot volume. Volume estimates are the maximum potential volume before deductions for defects (Tables 2a and 2b).

Comparing the Tools

You can use Table 3 to compare the tools. Begin by checking the key at the bottom. The size of the square, from small (least exact) to large (most exact), indicates the tool's degree of precision; the square's color indicates how difficult it is to use (black denotes easy, white denotes difficult). In the table's far-left column, find the factors you intend to measure and cross-reference them with the tools listed at the top. Some tools are quick and easy to use, but yield only approximate results. Others are more difficult to use and might or might

not yield more precise results. Select the tool that best meets your needs.

For example, if you want to measure the grade of a road, you can choose between two tools: the abney hand level and the clinometer. The abney hand level shows a large square (indicating high relative precision) that is gray (indicating it is moderately difficult to use). The clinometer shows a medium-sized square (it is moderately precise) that is all black (it is easy to use).

Availability

Some of the tools discussed in this fact sheet are available locally. All may be purchased from forestry supply houses (listed below), any of which will send you a catalog on request. The list is not complete and inclusion in the list does not constitute endorsement by Maryland Cooperative Extension. Your county Extension office or county Department of Natural Resources Forest Service office might have supply catalogs you can use to place orders.

Ben Meadows Company
3589 Broad Street
Atlanta, GA 30341
1-800-241-6401

Forestry Suppliers, Inc.
205 West Rankin Street
P.O. Box 8397
Jackson, MI 39204
1-800-647-5368

General Supply Corporation
P.O. Box 9347
303 Commerce Park Drive
Jackson, MS 39286-9347
1-800-647-6450

International Reforestation Suppliers
2100 W. Broadway
P.O. Box 5547
Eugene, OR 97405
1-800-321-1037

References

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Beattie, M., C. Thompson, and L. Levine. 1993. *Working With Your Woodland: A Landowner's Guide.* Hanover, NH: University Press of New England.

Walker, L.C. 1988. *Farming the Small Forest.* San Francisco, CA: Miller Freeman Publications, Inc.

This fact sheet is part of a series on woodland management. If you would like information on additional topics in the series, contact your county Extension office.

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