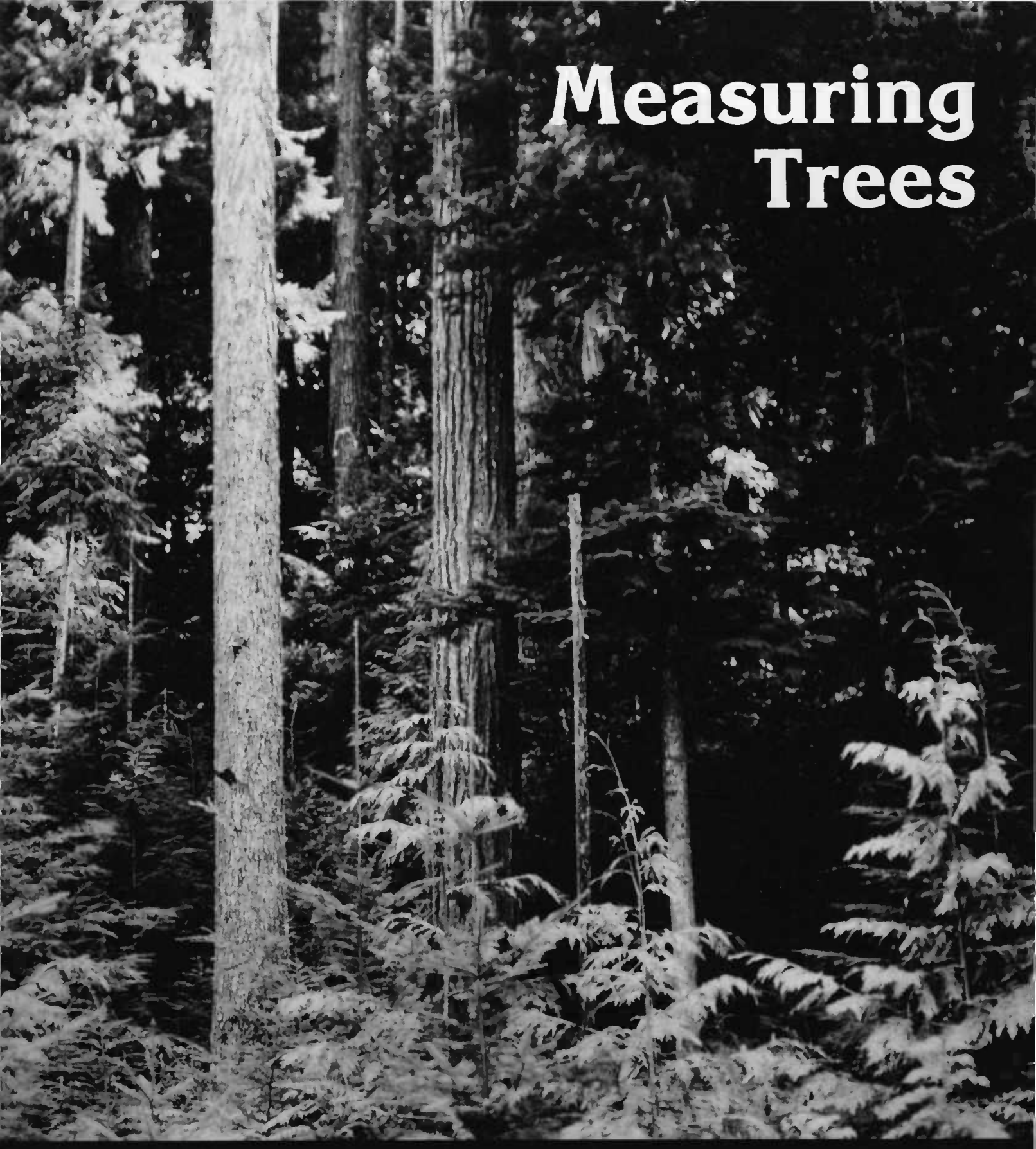

Measuring Trees

A Pacific Northwest Extension Publication
Oregon • Washington • Idaho
PNW 31
Revised June 1982

Contents

Knowing the quantity and quality of forest products contained on woodland property is essential to its best management. Thus, the woodland owner has a vital interest in the measurement of logs, trees, and forest stands. The increased value of forest products has placed greater emphasis on their measurement.

This publication is designed to acquaint nonindustrial woodland owners with the methods of determining the quantity and quality of various forest products. It will serve as a reference for those needing a basic guide to measurements, and it will provide information on which to base further questions.

Managing a woodland

Woodland owners may have dealt for years with bushels of grain or tons of hay per acre but still may not know how to measure the volume and value of various wood products in the farm woodland. If the seller knows the quality and quantity of the timber, he or she can dispose of any portion of it in a businesslike manner.

To determine the volume of products contained in a woodland, make an inventory or cruise. This inventory should determine the amount of merchantable products in terms of board feet for saw logs; in cords, cubic feet, or tons for pulpwood and fuelwood; and in lineal feet for poles, piling, and posts. By knowing the prevailing prices, size, and quality requirements for the various products, you can determine which of these items gives you the greatest cash return.

Usually it is best to sell the larger trees as saw logs and peeler logs. You can sell smaller trees taken out in thinnings for small poles, pulpwood, or logs, depending on their quality and the markets available. Before you cut trees for forest products, it is wise to check with prospective purchasers.

In addition to knowing the volume and the value of your wood crop, you should know something about farming your timber. Timber is a crop. Like other agricultural crops, it grows in the soil and is responsive to good management. Good timber management will increase the total income. An inventory, kept up to date, is an aid in timber farming. It is an accepted practice that a grocer keep an inventory of goods on the shelf. So must a timber farmer keep an inventory of the trees in a woodland.

Units of measure

The five units by which trees and logs usually are measured are the board foot, the cubic foot, the cord, the lineal foot, and weight. Measuring by the board foot is most common. The board foot unit represents an unplaned board 1 foot long, 1 foot wide, and 1 inch thick, or its equivalent. You can obtain the board foot content of any board by multiplying the three nominal dimensions (width and thickness in inches; length in feet) and dividing the product by 12. For example, a 2 x 4 that is 8 feet long would have 5⅓ board feet:

$$\frac{2'' \times 4'' \times 8'}{12} = 5\frac{1}{3}$$

The cubic foot is a solid piece of wood 1 foot wide, 1 foot thick, and 1 foot long. This unit is considered to be the most accurate of those in common use because it comes the closest to consistently determining the volume of a log regardless of its size. However, most transactions in the wood products industry are based on the board foot. The cubic foot measure is used for determining the volume of pulpwood.

The cord is the unit for measuring the volume of stacked wood. The standard cord is a pile 4 feet high, 4 feet wide, and 8 feet long. Although the standard cord contains 128 cubic feet of space, the amount of actual wood varies by size and uniformity of the pieces. The solid wood content in a cord is seldom more than 90 cubic feet. The bark and the combined empty spaces between the pieces of wood make up the rest of the total space in the cord.

A short cord or face cord is a unit commonly used for fuelwood measurement. The face cord is a stack of wood 4 feet high and 8 feet long, but the pieces of wood are less than 4 feet in length. Thus, the face cord contains less wood than the standard cord.

Specifications for various timber products— grading

Each woodland contains a variety of products, and each individual tree has a specific best use and highest value. The importance of grading (assessing the quality of a log or tree) timber products has increased as prices have increased.

Saw logs and peeler logs

It requires considerable experience and skill to properly assign grades to individual logs and especially to logs within standing trees. Three important factors in assigning log grades are diameter, size and quantity of knots, and grain (the number of annual rings per inch).

The various log grades for important species as defined by the Northwest Log Rule Advisory Group appear in a booklet available from Northwest log-scaling bureaus.

Poles and piling

Poles and piling have rigid specifications that are rather complicated. Pole buyers are most helpful in interpreting these specifications and assessing the quantity and quality of poles in a given stand. The American Standards Association has set up size classes and requires straight, uniform trees, free from defects and excessive roughness.

At present most Douglas-fir poles and piling are sold as "barkies" (unpeeled) and are peeled mechanically before treating.

Pulpwood

Size specifications for pulpwood vary in both diameter and length. Species most used for pulpwood include western hemlock, white fir, spruce, lodgepole pine, alder, cottonwood, and Douglas-fir. Pulpwood is usually sold by the standard cord (4′ x 4′ x 8′), by the cubic foot, or by weight.

Fuelwood

Fuelwood generally is sold by the cord. Length and diameter specifications vary, but larger pieces are usually split.

Measuring volume of logs—scaling

Board-foot volume

Scaling is the process for determining the volume of logs. The primary goal of log scaling is to obtain a uniform measure of the volume that is acceptable to buyer and seller. The volume of logs is generally expressed in board feet. The log rule (procedure for calculating the volume of a log) normally used in western United States is the Scribner log rule (see table 1). The volumes are often listed in tens of board feet, which is called Scribner Decimal C. When you use the Scribner log rule for small logs, there is considerable overrun. The difference between the board foot estimate (log rule measurement) and actual cut (lumber tally) from a log is called overrun when the lumber tally is greater than the estimate. Underrun is the difference when the lumber tally is less than the estimate. These are usually expressed as a percent of the estimated volume. Figure 1 shows that, based on one study, the overrun varies by diameter.

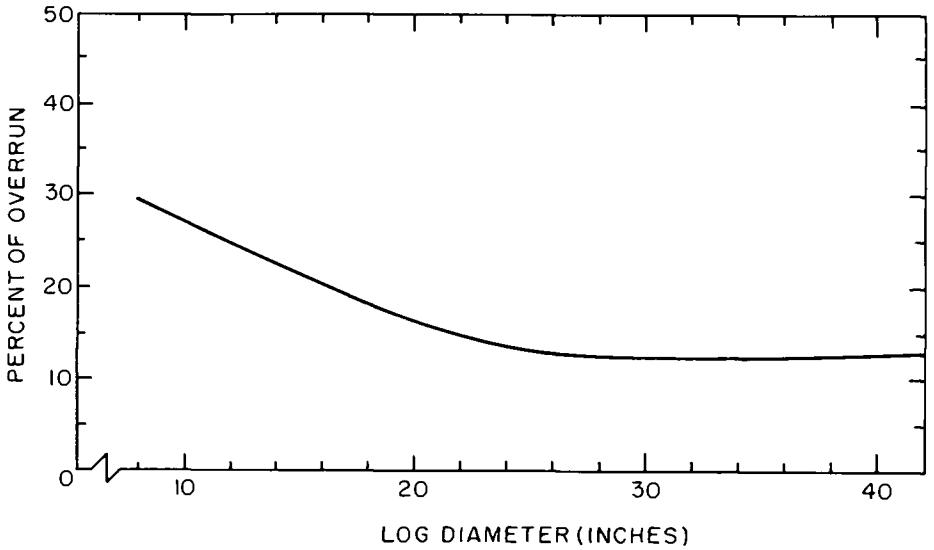

Figure 1. Overrun from Douglas-fir logs (Scribner log rule)

As noted in table 1, you must measure the diameter and the length of the log in order to determine the volume. Measure the diameter at the small end of the log (inside bark). This diameter is called the "scaling diameter." For oval-shaped logs, determine the scaling diameter by averaging the long and the short diameter measurements. In measuring scaling diameters, drop any fraction over the inch. Measure saw log length in either 1- or 2-foot multiples. Scale individual logs as two separate logs if they are longer than 40 feet west of the Cascades or 20 feet east of the Cascades. Each of these logs is as nearly the same length as possible. In addition, all board-foot log rules make an allowance for the material removed, slabs, and sawdust (kerf) when the logs are sawn.

Cubic-foot volume

There is increased interest in the use of cubic-foot volume because of the large overrun for small logs when using the Scribner board-foot log rule (see figure 1). When you determine the cubic-foot volume of a log, make no allowance for kerf or slab.

A common cubic-foot log rule is the Smalian log rule: measure the diameter at both ends of the log and the log length. Table 2 gives cubic-foot volumes based on the Smalian log rule.

Tree volume tables

Volumes of individual trees are determined using tree volume tables. The three main factors affecting the volume of a tree are diameter, height, and form (amount of taper). Tree volume tables vary from one another in the way diameter, height, and form are incorporated into each table. There are four major types of volume tables: standard, local, form class, and tarif.

Standard volume tables

A standard volume table is based on diameter and height and assumes an average form. The table is based on a large number of measurements and it is usually best suited for only one species. Tables 3 through 8 are examples of standard volume tables.

Local volume tables

Local volume tables are derived from standard volume tables. An average height and form are incorporated into the table for the stand. Therefore, in determining the volume of an individual tree in a stand, the only measurement you take is diameter. Since stands vary one from another, a local volume table can only be used for the stand from which the data were collected.

Form class tables

It is usually easier and more accurate to use form class or tarif volume tables for a given stand than a local table. A form class table is essentially a standard volume table adapted to one particular form class. Thus, in these tables, diameter, height, and form are all considered. Form class tables apply regardless of species or locality. Form class is the ratio obained by dividing the scaling diameter of the butt (bottom) log in the tree by diameter breast height (DBH). Form class tables are available on the basis of 16-foot log lengths (generally used on the east side of the Cascades) and 32-foot log lengths (generally used on the west side of the Cascades). Thus, tree height is expressed as the number of 16- or 32-foot logs that the tree contains. A book of form class tables can be purchased from Mason, Bruce, and Girard, foresters, American Bank Building, Portland, Oregon 97205.

To use form class tables properly, determine the correct form class. This is done by measuring 25 trees (for each species), well distributed over the range of diameters occurring in the stand. Thus, the major disadvantage of the form class tables is in determining the correct form class. Another disadvantage is that they can only be used for trees with diameters 12 inches and above.

Tarif volume tables

There is an increased interest in the use of tarif volume tables. These are local volume tables that give tree volume by diameters for trees of the same general height class. The tarif tree volume system is of European origin and has been adapted for use in the Pacific Northwest by the Department of Natural Resources, State of Washington (they are available from the department, Olympia). The tarif system is a series of local volume tables well suited to, but not limited

Table 1. Scribner log rule, board-foot volume

Top diameter of log inches	Log Length -- Feet																																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	↓	↓	↓	↓	↓	↓	↓	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10
3	↓	↓	↓	↓	↓	↓	↓	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	20	20
4	↓	↓	↓	↓	↓	↓	↓	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	20	20	20	20	20	20	20	20	20	20	20	20	20	20	30	30	30	30
5	↓	↓	↓	↓	10	10	10	10	10	10	10	10	10	10	20	20	20	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	40	40	40	40	40	40	40
6	↓	↓	↓	↓	10	10	10	10	10	10	10	10	20	20	20	20	20	20	20	20	30	30	30	30	30	30	30	30	40	40	40	50	50	50	50	60	60	60	60	60
7	↓	↓	↓	10	10	10	10	10	10	10	20	20	20	20	30	30	30	30	30	30	30	40	40	40	40	40	40	50	50	50	50	50	60	60	60	60	70	70	70	70
8	↓	↓	↓	10	10	10	10	10	10	20	20	20	20	20	20	30	30	30	40	40	40	40	40	40	50	50	50	50	50	60	60	70	70	70	80	80	80	80	90	90
9	↓	↓	10	10	10	10	10	20	20	20	20	30	30	30	30	40	40	40	50	50	50	50	60	60	60	60	70	70	70	70	70	90	100	100	100	100	110	110	110	120
10	↓	10	10	10	20	20	20	30	30	30	30	40	40	40	50	60	60	60	70	70	70	80	80	90	90	90	100	100	100	110	110	120	130	130	130	140	140	140	150	150
11	↓	10	10	10	20	20	30	30	30	40	40	40	50	50	60	70	70	80	80	80	90	90	100	100	100	110	110	120	120	130	130	140	150	150	160	160	170	170	180	180
12	↓	10	10	20	20	30	30	40	40	50	50	60	60	70	70	80	80	90	90	100	100	110	110	120	120	130	130	140	140	150	150	160	160	170	170	180	180	190	190	200
13	10	10	20	20	30	40	40	50	50	60	70	70	80	80	90	100	100	110	110	120	130	130	140	150	150	160	160	170	180	180	190	190	200	210	210	220	220	230	240	240
14	10	10	20	30	40	40	50	60	60	70	80	90	90	100	110	110	120	130	140	140	150	160	160	170	180	190	190	200	210	210	220	230	240	240	250	260	260	270	280	290
15	10	20	30	40	40	50	60	70	80	90	100	110	120	120	130	140	150	160	170	180	190	200	200	210	220	230	240	250	260	270	280	280	290	300	310	320	330	340	350	360
16	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400
17	10	20	30	50	60	70	80	90	100	120	130	140	150	160	170	180	200	210	220	230	240	250	270	280	290	300	310	320	330	350	360	370	380	390	400	420	430	440	450	460
18	10	30	40	50	70	80	90	110	120	130	150	160	170	190	200	210	230	240	250	270	280	290	310	320	330	350	360	370	390	400	410	430	440	450	470	480	490	510	520	530
19	10	30	40	60	70	90	100	120	130	150	160	180	190	210	220	240	250	270	280	300	310	330	340	360	370	390	400	420	430	450	460	480	490	510	520	540	550	570	580	600
20	20	30	50	70	90	100	120	140	160	170	190	210	230	240	260	280	300	310	330	350	370	380	400	420	440	450	470	490	510	520	540	560	580	590	610	630	650	660	680	700
21	20	40	60	80	90	110	130	150	170	190	210	230	250	270	280	300	320	340	360	380	400	420	440	460	470	490	510	530	550	570	590	610	630	650	660	680	700	720	740	760
22	20	40	60	80	100	130	150	170	190	210	230	250	270	290	310	330	350	380	400	420	440	460	480	500	520	540	560	580	610	630	650	670	690	710	730	750	770	790	810	840
23	20	50	70	90	120	140	160	190	210	240	260	280	310	330	360	380	400	410	450	470	490	520	540	560	590	610	630	660	680	710	730	750	780	800	820	850	870	890	920	940
24	30	50	80	100	130	150	180	200	230	250	280	300	330	350	380	400	430	450	480	500	530	550	580	610	630	660	680	710	730	760	780	810	830	860	880	910	930	960	980	1010
25	30	60	90	110	140	170	200	230	260	290	320	340	370	400	430	460	490	520	540	570	600	630	660	690	720	750	770	800	830	860	890	920	950	980	1000	1030	1060	1090	1120	1150
26	30	60	90	120	160	190	220	250	280	310	340	370	410	440	470	500	530	560	590	620	660	690	720	750	780	810	840	870	910	940	970	1000	1030	1060	1090	1120	1160	1190	1220	1250
27	30	70	100	140	170	210	240	270	310	340	380	410	440	480	510	550	580	620	650	680	720	750	790	820	860	890	920	960	990	1030	1060	1100	1130	1160	1200	1230	1270	1300	1330	1370
28	40	70	110	150	180	220	250	290	330	360	400	440	470	510	550	580	620	650	690	730	760	800	840	870	910	950	980	1020	1050	1090	1130	1160	1200	1240	1270	1310	1360	1380	1420	1460
29	40	80	110	150	190	230	270	300	340	380	420	460	490	530	570	610	650	680	720	760	800	840	870	910	950	990	1030	1070	1100	1140	1180	1220	1260	1290	1330	1370	1410	1450	1480	1520
30	40	80	120	160	210	250	290	330	370	410	450	490	530	590	620	660	700	740	780	820	860	900	940	990	1030	1070	1110	1150	1190	1230	1270	1310	1350	1400	1440	1480	1520	1560	1600	1640
31	40	90	130	180	220	270	210	360	400	440	490	530	580	620	670	710	750	800	840	890	930	980	1020	1070	1110	1150	1200	1240	1290	1330	1380	1420	1460	1510	1550	1600	1640	1690	1730	1780
32	50	90	140	180	230	280	320	370	410	460	510	550	600	640	690	740	780	830	870	920	970	1010	1060	1100	1150	1200	1240	1290	1330	1380	1430	1470	1520	1560	1610	1660	1700	1750	1790	1840
33	50	100	150	200	240	290	340	390	440	490	540	590	640	690	730	780	830	880	930	980	1030	1080	1130	1180	1220	1270	1320	1370	1420	1470	1520	1570	1620	1670	1710	1760	1810	1860	1910	1960
34	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000
35	50	110	160	220	270	330	380	440	490	550	600	660	710	770	820	880	930	980	1040	1090	1150	1200	1260	1310	1370	1420	1480	1530	1590	1640	1700	1750	1800	1860	1910	1970	2020	2080	2130	2190
36	60	120	170	230	290	350	400	460	520	580	630	690	750	810	860	920	980	1040	1100	1150	1210	1270	1330	1380	1440	1500	1560	1610	1670	1730	1790	1850	1900	1960	2020	2080	2130	2190	2250	2310
37	60	130	190	260	320	390	450	510	580	640	710	770	840	900	960	1030	1090	1160	1220	1290	1350	1420	1480	1540	1610	1670	1740	1800	1870	1930	1990	2060	2120	2190	2250	2320	2380	2440	2510	2570
38	70	130	200	270	330	400	470	530	600	670	730	800	870	930	1000	1070	1130	1200	1270	1330	1400	1470	1530	1600	1670	1740	1800	1870	1940	2000	2070	2140	2200	2270	2340	2400	2470	2540	2600	2670
39	70	140	210	280	350	420	490	560	630	700	770	840	910	980	1050	1120	1190	1260	1330	1400	1470	1540	1610	1680	1750	1820	1890	1960	2030	2100	2170	2240	2310	2380	2450	2520	2590	2660	2730	2800
40	80	150	230	300	380	450	530	600	680	750	830	900	980	1050	1130	1200	1280	1350	1430	1500	1580	1660	1730	1810	1880	1960	2030	2110	2180	2260	2330	2410	2480	2560	2630	2710	2780	2860	2930	3010

Table 2. Cubic-foot log volume[a]

Top diameter of log inches	Log length--feet																				
	6	8	10	12	14	16	17	18	20	22	24	26	28	30	32	34	35	36	38	40	42
	Cubic Feet																				
4	.6	.9	1.2	1.5	1.9	2.3	2.5	2.7	3.2	3.7	4.3	4.9	5.5	6.2	7.0	7.8	8.2	8.7	9.6	10.6	11.6
5	1.0	1.3	1.7	2.2	2.7	3.2	3.5	3.8	4.4	5.1	5.8	6.6	7.4	8.3	9.2	10.3	10.8	11.3	12.4	13.6	14.9
6	1.3	1.9	2.4	3.0	3.7	4.4	4.7	5.1	5.9	6.8	7.7	8.6	9.6	10.7	11.9	13.1	13.7	14.4	15.7	17.1	18.6
7	1.8	2.5	3.2	4.0	4.8	5.7	6.1	6.6	7.6	8.6	9.8	10.9	12.2	13.5	14.8	16.3	17.0	17.8	19.4	21.1	22.8
8	2.3	3.2	4.1	5.0	6.1	7.2	7.7	8.3	9.5	10.8	12.1	13.5	15.0	16.5	18.2	19.8	20.7	21.6	23.5	25.4	27.4
9	2.9	3.9	5.1	6.3	7.5	8.8	9.5	10.2	11.6	13.1	14.7	16.4	18.1	19.9	21.8	23.8	24.8	25.8	28.0	30.2	32.5
10	3.5	4.8	6.2	7.6	9.1	10.6	11.5	12.2	14.0	15.8	17.6	19.5	21.6	23.6	25.8	28.1	29.3	30.5	32.9	35.5	38.1
11	4.2	5.8	7.4	9.1	10.8	12.7	13.6	14.6	16.5	18.6	20.7	23.0	25.3	27.7	30.2	32.8	34.1	35.5	38.2	41.1	44.1
12	5.0	6.8	8.7	10.7	12.7	14.8	15.9	17.0	19.3	21.7	24.2	26.7	29.3	32.1	34.9	37.8	39.3	40.9	44.0	47.2	50.6
13	5.9	8.0	10.1	12.4	14.8	17.2	18.4	19.7	22.2	25.0	27.8	30.7	33.7	36.8	40.0	43.3	44.9	46.7	50.2	53.8	57.5
14	6.8	9.2	11.7	14.3	17.0	19.7	21.1	22.6	25.4	28.6	31.7	35.0	38.3	41.8	45.4	49.1	50.9	52.8	56.7	60.8	64.9
15	7.7	10.5	13.3	16.3	19.3	22.4	24.0	25.7	29.0	32.4	35.9	39.6	43.3	47.2	51.1	55.2	57.3	59.4	63.7	68.2	72.7
16	8.8	11.9	15.1	18.4	21.8	25.3	27.1	28.9	32.6	36.5	40.4	44.4	48.6	52.9	57.2	61.8	64.1	66.4	71.1	76.0	81.0
17	9.9	13.4	17.0	20.7	24.5	28.4	30.4	32.4	36.5	40.7	45.1	49.6	54.2	58.9	63.7	68.7	71.2	73.2	79.0	84.3	89.8
18	11.0	14.9	18.9	23.0	27.3	31.6	33.8	36.0	40.4	45.3	50.1	55.0	60.0	65.2	70.5	75.9	78.7	81.5	87.2	93.0	99.0
19	12.3	16.6	21.0	25.6	30.2	35.0	37.4	39.9	44.9	50.0	55.3	60.7	66.2	71.9	77.7	83.6	86.6	89.7	95.9	102.2	108.7
20	13.6	18.3	23.2	28.2	33.3	38.6	41.2	43.9	49.4	55.0	60.8	66.7	72.7	78.9	85.2	91.6	94.9	98.2	104.9	111.8	118.8
21	15.0	20.2	25.5	31.0	36.6	42.3	45.2	48.2	54.2	60.3	66.6	73.0	79.5	86.2	93.0	100.0	103.5	107.1	114.4	121.8	129.4
22	16.4	22.1	27.9	33.9	40.0	46.2	49.4	52.6	59.1	65.8	72.6	79.5	86.6	93.8	101.2	108.8	112.6	116.5	124.3	132.3	140.5
23	17.9	24.1	30.5	37.0	43.6	50.4	53.8	57.3	64.1	71.5	78.9	86.4	94.0	101.8	109.8	117.9	122.0	126.2	134.6	143.2	152.0
24	19.4	26.2	33.1	40.1	47.3	54.6	58.3	62.1	69.7	77.5	85.4	93.5	101.7	110.1	118.7	127.4	131.8	136.3	145.3	154.6	164.0
25	21.1	28.4	35.8	43.4	51.2	59.1	63.1	67.1	75.3	83.7	92.2	100.9	109.7	118.8	127.9	137.3	142.0	146.8	156.5	166.3	176.4
26	22.8	30.7	38.7	46.9	55.2	63.7	68.0	72.4	81.2	90.1	99.3	108.6	118.1	127.7	137.5	147.5	152.6	157.7	168.0	178.6	189.3
27	24.5	33.0	41.6	50.4	59.4	68.5	73.1	77.8	87.2	96.8	106.6	116.6	126.7	137.0	147.5	158.1	163.5	169.0	180.0	191.2	202.6
28	26.4	35.5	44.7	54.1	63.7	73.5	78.4	83.4	93.5	103.8	114.2	124.8	135.6	146.6	157.8	169.1	174.9	180.7	192.4	204.3	216.4
29	28.2	38.0	47.9	58.0	68.2	78.6	83.9	89.2	100.0	110.9	122.1	133.4	144.9	156.5	168.4	180.5	186.6	192.7	205.2	217.8	230.7
30	30.2	40.6	51.2	61.9	72.8	83.9	89.6	95.2	106.7	118.3	130.2	142.2	154.4	166.8	179.4	192.2	198.7	205.2	218.4	231.8	245.4
31	32.2	43.3	54.5	66.0	77.6	89.4	95.4	101.4	113.6	126.0	138.6	151.3	164.3	177.4	190.8	204.3	211.2	218.1	232.0	246.2	260.6
32	34.3	46.1	58.1	70.2	82.6	95.1	101.5	107.8	120.8	133.9	147.2	160.7	174.4	188.3	202.5	216.8	224.0	231.3	246.1	261.0	276.2
33	36.5	49.0	61.7	74.6	87.7	101.0	107.7	114.4	128.1	142.0	156.1	170.4	184.9	199.6	214.5	229.6	237.3	245.0	260.5	276.3	292.3
34	38.7	51.9	65.4	79.1	92.9	107.0	114.1	121.2	135.7	150.4	165.3	180.3	195.6	211.2	226.9	242.8	250.9	259.0	275.4	292.0	308.8
35	41.0	55.0	69.2	83.7	98.3	113.2	120.7	128.2	143.5	159.0	174.7	190.6	206.7	223.1	239.6	256.4	264.9	273.4	290.7	308.2	325.9
36	43.3	58.1	73.2	88.4	103.9	119.6	127.5	135.4	151.5	167.8	184.4	201.1	218.1	235.3	252.7	270.4	279.3	288.3	306.4	324.7	343.3
37	45.7	61.4	77.2	93.3	109.6	126.1	134.4	142.8	159.8	176.9	194.3	211.9	229.8	247.8	266.2	284.7	294.1	303.5	322.5	341.7	361.2
38	48.2	64.7	81.4	98.3	115.5	132.8	141.6	150.4	168.2	186.3	204.5	223.0	241.8	260.7	279.9	299.4	309.2	319.1	339.0	359.2	379.6
39	50.7	68.1	85.7	103.4	121.5	139.7	148.9	158.2	176.9	195.8	215.0	234.4	254.1	273.9	294.1	314.5	324.7	335.1	356.0	377.1	398.5
40	53.3	71.6	90.0	108.7	127.6	146.8	156.4	166.2	185.8	205.6	225.7	246.1	266.7	287.5	308.6	329.9	340.7	351.5	373.3	395.4	417.8

[a]Smalian log rule: taper allowance 1 inch in 8 feet of log length.

Table 3. Board-foot volume for second-growth Douglas-fir

Inches DBH outside bark	Number of 16-foot logs in tree								
	1	2	3	4	5	6	7	8	9
12.....	62	80	133	183	235	286	338		
14.....	64	88	147	210	274	338	400		
16.....	67	96	163	242	320	399	478		
18.....	71	109	190	280	370	459	550	640	729
20.....	75	123	221	330	435	543	651	758	865
22.....	80	136	258	383	509	633	760	884	1,011
24.....		151	292	438	584	728	882	1,035	1,188
26.....		170	333	500	666	832	1,013	1,190	1,368
28.....		188	371	560	750	941	1,144	1,346	1,551
30.....				638	850	1,062	1,291	1,518	1,749
32.....				716	955	1,195	1,449	1,700	1,954
34.....				791	1,059	1,333	1,614	1,898	2,180
36.....				882	1,175	1,494	1,782	2,095	2,410
38.....				978	1,290	1,614	1,955	2,305	2,660
40.....					1,410	1,779	2,150	2,523	2,892

Trees scaled in 16-foot logs with 0.3-foot trimming allowance to 8 inches DIB in top, Scribner rule. Stump height 2.0 feet.

Table 4. Total cubic volume, inside bark, including stump and top—ponderosa pine (Source: Faurot, *Estimating Merchantable Volume and Stem Residue in Four Timber Species,* U.S. Forest Service Research Paper INT-196, November 1977)

D.b.h. (inches)	Total height (feet)												Sample size
	10	20	30	40	50	60	70	80	90	100	110	120	130	
	Cubic feet													*No. trees*
2	0.17	0.23	0.30	0.40	0.53	0.70								21
3	0.40	0.52	0.67	0.86	1.11	1.44								22
4	0.72	0.92	1.17	1.49	1.89	2.41	3.06							38
5		1.44	1.81	2.28	2.86	3.59	4.50	5.65						23
6		2.08	2.59	3.22	4.00	4.97	6.17	7.67						12
7		2.84	3.50	4.31	5.31	6.54	8.06	9.93	12.23					12
8		3.72	4.54	5.56	6.79	8.31	10.16	12.42	15.19					13
9			5.72	6.95	8.44	10.25	12.45	15.13	18.37	22.32				15
10			7.03	8.49	10.25	12.38	14.94	18.05	21.79	26.31				20
11			8.47	10.17	12.22	14.67	17.62	21.17	25.42	30.54				12
12				12.00	14.34	17.14	20.49	24.49	29.27	34.98	41.81			23
13				13.97	16.62	19.78	23.53	28.00	33.32	39.64	47.17			17
14				16.08	19.05	22.58	26.75	31.70	37.56	44.51	52.74	62.49		20
15				18.33	21.64	25.54	30.14	35.58	42.00	49.57	58.51	69.06		24
16				20.72	24.37	28.66	33.71	39.64	46.62	54.83	64.48	75.84		25
17				23.25	27.25	31.94	37.44	43.88	51.43	60.28	70.65	82.80		21
18					30.28	35.37	41.33	48.28	56.41	65.91	77.00	89.96		13
19					33.45	38.96	45.38	52.86	61.57	71.71	83.53	97.29		12
20						42.70	49.59	57.60	66.90	77.70	90.24	104.81		12
21						46.59	53.96	62.50	72.39	83.85	97.12	112.49	130.29	4
22						50.63	58.49	67.56	78.05	90.17	104.17	120.34	139.02	2
23							63.16	72.78	83.87	96.65	111.38	128.35	147.90	1
24								78.16	89.85	103.30	118.75	136.52	156.94	0

Log V = -1.52198 +2.12327 (log D) +0.0138002 (H) -0.00561155 (log D) (H)
S.O. of coeff. 0.0231878 0.000552903 0.000420125
S.E. = 0.04413

Mean error = 10.5 percent
Ave. bias = -0.73 percent
Ave. deviation = 7.9 percent

Table 5. Top cubic volume, inside bark (4-inch top diameter)—ponderosa pine (Source: Faurot)

D.b.h. (inches)	Total height (feet)												Sample size
	10	20	30	40	50	60	70	80	90	100	110	120	130	
	Cubic feet													*No. trees*
6		1.390	1.674	1.910	2.116	2.301	2.470	2.626						2
7		1.113	1.362	1.572	1.757	1.924	2.078	2.221	2.355					11
8		0.918	1.139	1.328	1.496	1.648	1.789	1.921	2.046					13
9			0.973	1.145	1.298	1.438	1.568	1.691	1.807	1.917				15
10			0.846	1.002	1.143	1.273	1.394	1.508	1.616	1.720				20
11			0.744	0.888	1.019	1.139	1.253	1.360	1.462	1.559				12
12			0.663	0.796	0.917	1.030	1.136	1.237	1.333	1.426	1.515			23
13			0.595	0.719	0.833	0.939	1.039	1.134	1.225	1.313	1.398			17
14			0.539	0.655	0.762	0.862	0.956	1.046	1.133	1.217	1.298	1.376		20
15			0.492	0.600	0.701	0.795	0.885	0.971	1.054	1.134	1.211	1.286		24
16				0.553	0.648	0.738	0.823	0.905	0.984	1.061	1.135	1.207		25
17				0.513	0.603	0.688	0.769	0.848	0.923	0.997	1.068	1.138		21
18				0.477	0.563	0.644	0.722	0.797	0.869	0.940	1.008	1.076		13
19				0.445	0.517	0.605	0.679	0.751	0.821	0.889	0.955	1.020		12
20				0.417	0.495	0.570	0.641	0.711	0.778	0.843	0.907	0.970		12
21						0.538	0.607	0.674	0.739	0.802	0.864	0.924	0.984	4
22						0.510	0.576	0.641	0.703	0.764	0.824	0.883	0.941	2
23							0.548	0.610	0.671	0.730	0.788	0.845	0.902	1
24								0.583	0.642	0.699	0.755	0.811	0.865	0

Log V = 1.26403 -2.20809 (log D) +0.58980 (log D) (log H)
S.D. of coeff. 0.155923 0.0615612
S.E. = 0.06761

Mean error = 15.7 percent
Ave. bias = -1.5 percent
Ave. deviation = 12.2 percent

to, even-aged stands. Each table is identified by a tarif number that is the cubic-foot volume to a 4-inch top diameter for a tree of 1-square-foot basal area (basal area is the cross-sectional area at breast height expressed in square feet).

Thus a tarif table is really a local volume table that gives the tree volume by diameter for trees of the same general height class. The tables give both board foot and cubic foot volumes. Cubic foot tree volumes are listed to 4-, 6-, and 8-inch top diameter and for the total tree. The board foot volumes are listed in terms of 16- and 32-foot logs to 6- and 8-inch top diameters. In addition, formulas for use with computers are available for determining tree volumes. An example of a tarif volume table is given in table 9.

To determine average tarif number, select a minimum of 20 trees representing the range of diameters in the stand in which you are interested. For each selected tree, measure diameter breast height to nearest 0.1 inch and total height of the tree to the nearest even foot. Determine the tarif number for each measured tree from the appropriate tarif access table (see table 10). Calculate average tarif number for use with comprehensive tarif tables to obtain the volume of each tree measured in the cruise.

The following example shows how to determine the average tarif number based on 20 trees for a Douglas-fir stand.

DBH	*Total height*	*Tarif number**
13.5	106	40.6
10.3	80	33.5
25.1	98	29.8
16.0	94	33.6
17.7	110	38.2
19.0	100	33.7
6.9	62	30.1
11.8	102	41.0
13.1	100	38.6
5.9	74	39.4
22.0	112	36.0
15.2	108	39.6
9.3	82	35.8
8.7	90	40.6
18.7	112	38.2
21.6	114	36.9
12.7	98	38.3
27.0	110	32.8
19.0	102	34.4
17.3	108	37.8
		728.9

* From table 10, average tarif number $\frac{728.9}{20}$ = 36.45 = 36.5. The volume for each tree in the cruise would be obtained from table 9, which is only one table from a book that includes similar tables for tarif 10 through 70 for each whole and half tarif number.

Table 6. Cubic-foot and board-foot volume for Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) (Source: University of Idaho College of Forestry Station Note 27, December 1976)

Cubic-foot Volume

TOTAL TREE HEIGHT (in feet)

DBH (inches)	10	20	30	40	50	60	70	80	90	BASIS (no. trees)
2	0.24	0.31	0.38	0.46	0.53					14
3	0.33	0.49	0.65	0.82	0.98					26
4	0.46	0.74	1.03	1.32	1.61	1.89				27
5	0.62	1.07	1.52	1.96	2.41	2.86				23
6	0.82	1.46	2.11	2.75	3.40	4.05	4.69			17
7			2.81	3.69	4.57	5.45	6.33			24
8			3.62	4.76	5.91	7.06	8.21			13
9				5.99	7.44	8.89	10.35			8
10				7.35	9.14	10.94	12.73	14.53	16.32	1
11					11.03	13.20	15.37	17.55	19.72	1
12					13.09	15.68	18.26	20.85	23.43	1
13						18.37	21.40	24.44	27.47	1
14						21.28	24.80	28.32	31.83	0
BASIS (no. trees)	2	18	37	34	41	20	3	0	1	156

Cubic foot volume = $0.16949 + 0.001795D^2H$ ($r^2 = 0.985$)

Standard error of estimate = 0.2825 cu ft

Board-foot Volume

TOTAL TREE HEIGHT (in feet)

DBH (inches)	20	30	40	50	60	70	80	90	BASIS (no. trees)
2	0.35	0.68	1.02	1.36					0
3	1.19	1.94	2.70	3.45					7
4	2.36	3.71	5.05	6.39	7.74				24
5	3.87	5.97	8.07	10.17	12.27				23
6		8.74	11.77	14.79	17.81	20.83			17
7		12.02	16.13	20.24	24.36	28.47			24
8		15.80	21.17	26.54	31.91	37.29			13
9			26.88	33.68	40.48	47.28			8
10			33.26	41.65	50.05	58.44	66.84	75.23	1
11				50.47	60.62	70.78	80.94	91.10	1
12				60.12	72.21	84.30	96.39	108.48	1
13					84.80	98.99	113.18	127.36	1
14					98.40	114.86	131.31	147.76	0
BASIS (no. trees)	0	24	31	41	20	3	0	1	120

Board foot volume = $-0.32308 + 0.008395D^2H$ ($r^2 = 0.961$)

Standard error of estimate = 2.4706 bd ft

Table 7. Cubic-foot and board-foot volume for grand fir (*Abies grandis*) (Source: University of Idaho College of Forestry Station Note 27, December 1976)

Cubic-foot Volume

DBH (inches)	TOTAL TREE HEIGHT (in feet) 10	20	30	40	50	60	70	BASIS (no. trees)
2	0.08	0.17	0.26	0.34	0.43			44
3	0.19	0.39	0.58	0.77	0.97			41
4	0.34	0.69	1.03	1.38	1.72	2.07		32
5	0.54	1.07	1.61	2.15	2.69	3.23	3.77	14
6	0.77	1.55	2.32	3.10	3.87	4.65	5.42	5
7		2.11	3.16	4.22	5.27	6.33	7.38	9
8		2.75	4.13	5.51	6.89	8.27	9.64	9
9			5.23	6.97	8.72	10.46	12.21	2
10			6.46	8.61	10.76	12.92	15.07	0
11				10.42	13.02	15.63	18.23	0
12						18.60	21.70	0
	12	67	37	18	12	9	1	156

BASIS (no. trees)

Cubic foot volume = $-0.00167 + 0.002153D^2H$ ($r^2 = 0.985$)
Standard error of estimate = 0.1537 cu ft

Board-foot Volume

DBH (inches)	TOTAL TREE HEIGHT (in feet) 20	30	40	50	60	70	BASIS (no. trees)
2				0.13			0
3		0.82	1.71	2.60			2
4	1.31	2.89	4.48	6.06	7.64		24
5	3.09	5.56	8.03	10.50	12.97	15.44	13
6	5.27	8.82	12.38	15.94	19.49	23.05	5
7	7.83	12.68	17.52	22.36	27.20	32.04	9
8		17.12	23.45	29.77	36.09	42.42	9
9		22.16	30.17	38.17	46.17	54.18	2
10		27.79	37.68	47.56	57.44	67.32	0
11			45.98	57.93	69.89	81.84	0
12					83.52	97.75	0
	3	22	17	12	9	1	64

BASIS (no. trees)

Board foot volume = $-1.84883 + 0.009881D^2H$ ($r^2 = 0.939$)
Standard error of estimate = 2.6323 bd ft

Table 8. Region I volume table for ADP cruise computations—ponderosa pine Scribner board-foot volume (Source: U.S. Forest Service Handbook, June 1973, Amendment 3; table devised by P.D. Kemp)

DBH	040	050	060	070	080	090	100	110	120	130	140	150	160	170
10	1	10	22	34	46	58	70	82	94					
11	8	22	37	51	66	80	95	110	124	139				
12	19	36	53	71	88	105	123	140	157	174				
13	31	51	71	92	112	132	153	173	193	214	234			
14	44	67	91	114	138	162	185	209	232	256	279			
15	58	85	112	139	166	193	220	247	274	301	328	355		
16	73	103	134	165	196	226	257	288	319	349	380	411		
17	88	123	158	193	227	262	297	331	366	401	436	470	505	
18	105	144	183	222	261	300	339	378	417	456	494	533	572	
19	123	166	210	253	297	340	383	427	470	513	557	600	643	687
20	142	190	238	286	334	382	430	478	526	574	622	670	718	766
21					264	334	405	475	545	616	686	756	827	897
22					319	396	473	550	628	705	782	859	936	1014
23					376	461	545	629	714	798	882	967	1051	1136
24					436	528	620	712	804	896	987	1079	1171	1263
25					499	598	698	798	897	997	1097	1197	1296	1396
26					564	672	779	887	995	1103	1211	1319	1426	1534
27					631	748	864	980	1097	1213	1329	1445	1562	1678
28					702	827	952	1077	1202	1327	1452	1577	1702	1827
29					774	908	1043	1177	1311	1445	1579	1713	1847	1982
30					850	993	1137	1280	1424	1567	1711	1854	1998	2142
31					927	1081	1234	1387	1541	1694	1847	2000	2154	2307
32					1008	1171	1334	1498	1661	1824	1988	2151	2314	2478
33					1091	1264	1438	1612	1786	1959	2133	2307	2480	2654
34					1176	1361	1545	1729	1914	2098	2283	2467	2651	2836
35					1264	1460	1655	1850	2046	2241	2437	2632	2827	3023
36					1355	1562	1768	1975	2182	2388	2595	2802	3009	3215
37					1448	1666	1885	2103	2321	2540	2758	2977	3195	3413
38					1544	1774	2004	2235	2465	2695	2926	3156	3386	3617
39					1642	1885	2127	2370	2612	2855	3098	3340	3583	3825
40					1743	1998	2253	2508	2764	3019	3274	3529	3784	4040
41					1846	2114	2382	2651	2919	3187	3455	3723	3991	4259
42					1952	2233	2515	2796	3078	3359	3640	3922	4203	4484
43					2061	2355	2650	2945	3240	3535	3830	4125	4420	4715
44					2172	2480	2789	3098	3407	3716	4024	4333	4642	4951
45					2285	2608	2931	3254	3577	3900	4223	4546	4869	5192
46					2401	2739	3076	3414	3751	4089	4426	4764	5101	5439
47						2872	3225	3577	3929	4282	4634	4986	5339	5691
48						3009	3376	3744	4111	4479	4846	5214	5581	5949
49						3148	3531	3914	4297	4680	5063	5446	5829	6212
50						3290	3689	4087	4486	4885	5284	5682	6081	6480
51						3435	3850	4265	4680	5094	5509	5924	6339	6754
52							4014	4445	4877	5308	5739	6171	6602	7033
53							4182	4630	5078	5526	5974	6422	6870	7318
54							4352	4817	5282	5748	6213	6678	7143	7608
55							4526	5009	5491	5974	6456	6939	7421	7904
56							4703	5203	5704	6204	6704	7204	7704	8204
57							4883	5402	5920	6438	6956	7474	7993	8511
58							5067	5603	6140	6676	7213	7750	8286	8823
59							5253	5809	6364	6919	7474	8030	8585	9140
60							5443	6017	6592	7166	7740	8314	8888	9463

10 through 20-inch dbh

$$\text{Volume} = 1.201 \frac{(\text{dbh}^2 \times \text{height})}{100} - 50.340$$

21-inch dbh +

$$\text{Volume} = 1.595 \frac{(\text{dbh}^2 \times \text{height})}{100} - 298.784$$

U.S. Forest Service Handbook, June 1973, Amendment No. 3
Table developed by P.D. Kemp

Table 9. Example of a tarif volume table (Source: *Comprehensive Tree-Volume Tarif Tables,* 3rd ed., State of Washington, Department of Natural Resources, October 1980)

TOTAL TREE CU.FT. VOLUME						DBH	VOLUME TO A 4 INCH TOP IN CUBIC FEET			VOLUME TO A 6 INCH TOP												DBH
INCLUDING TOP AND STUMP			INCLUDING TOP ONLY							CUBIC FEET			BOARD FEET SCRIBNER						BOARD FEET INTERNATIONAL 1/4			
													16 FOOT LOGS			32 FOOT LOGS			16 FOOT LOGS			
VOL	V/BA	GM	VOL	V/BA	GM		VOL	V/BA	GM	VOL	V/BA	GM	VOL	V/BA	GM	VOL	V/BA	GM	VOL	V/BA	GM	
0.3	14.6	0.3	0.3	13.0	0.3	2																2
1.0	20.1	1.0	0.9	18.6	0.9	3																3
2.2	25.6	1.5	2.1	24.1	1.4	4																4
4.0	29.1	2.0	3.8	27.8	1.9	5	2.0	14.4	2.2													5
6.2	31.5	2.5	5.9	30.3	2.4	6	4.4	22.2	2.6													6
8.9	33.2	2.9	8.6	32.0	2.8	7	7.2	26.9	3.1	2.7	10.2	3.3	9.	33.9	12.1	7.	27.5	9.9	15.	54.6	17.9	7
12.0	34.5	3.4	11.6	33.3	3.3	8	10.5	30.0	3.5	6.4	18.3	4.0	24.	68.5	17.4	19.	55.7	14.2	35.	100.6	22.9	8
15.7	35.5	3.9	15.2	34.3	3.8	9	14.2	32.1	3.9	10.7	24.3	4.6	44.	98.6	21.7	35.	80.2	17.7	60.	135.9	26.8	9
19.8	36.3	4.4	19.2	35.1	4.2	10	18.3	33.6	4.4	15.5	28.4	5.0	67.	123.1	25.3	55.	100.1	20.6	88.	162.2	29.9	10
24.4	37.0	4.8	23.6	35.8	4.7	11	22.9	34.7	4.8	20.7	31.3	5.3	94.	142.4	28.4	76.	115.9	23.1	120.	181.6	32.8	11
29.5	37.5	5.3	28.5	36.3	5.1	12	27.9	35.5	5.2	26.1	33.3	5.7	124.	157.7	31.3	101.	128.4	25.5	154.	196.1	35.5	12
35.0	38.0	5.8	33.9	36.8	5.6	13	33.4	36.2	5.7	32.0	34.7	6.0	157.	169.9	34.1	127.	138.3	27.8	191.	207.1	38.3	13
41.0	38.4	6.2	39.7	37.1	6.0	14	39.3	36.7	6.1	38.1	35.7	6.3	192.	179.7	36.9	156.	146.4	30.2	231.	215.6	41.1	14
47.5	38.7	6.7	46.0	37.5	6.5	15	45.6	37.1	6.5	44.7	36.4	6.7	230.	187.8	39.8	188.	153.0	32.5	273.	222.5	43.9	15
54.4	39.0	7.2	52.7	37.7	6.9	16	52.3	37.5	7.0	51.5	36.9	7.1	272.	194.6	42.6	221.	158.6	34.9	318.	228.0	46.9	16
61.8	39.2	7.6	59.9	38.0	7.4	17	59.5	37.8	7.4	58.8	37.3	7.5	316.	200.3	45.6	258.	163.4	37.3	367.	232.7	49.9	17
69.7	39.4	8.1	67.5	38.2	7.8	18	67.2	38.0	7.9	66.5	37.6	7.9	363.	205.3	48.6	296.	167.6	39.8	418.	236.7	53.0	18
78.0	39.6	8.6	75.5	38.4	8.3	19	75.2	38.2	8.3	74.6	37.9	8.3	413.	209.7	51.6	337.	171.3	42.3	473.	240.1	56.2	19
86.8	39.8	9.0	84.0	38.5	8.7	20	83.8	38.4	8.7	83.1	38.1	8.7	466.	213.6	54.6	381.	174.5	44.8	531.	243.2	59.3	20
96.0	39.9	9.5	92.9	38.6	9.1	21	92.7	38.5	9.2	92.0	38.2	9.1	522.	217.0	57.6	427.	177.5	47.4	591.	245.9	62.5	21
105.7	40.0	9.9	102.3	38.8	9.6	22	102.1	38.7	9.6	101.3	38.4	9.6	581.	220.2	60.7	476.	180.2	50.0	655.	248.3	65.7	22
115.8	40.1	10.4	112.1	38.9	10.0	23	111.9	38.8	10.0	111.1	38.5	10.0	643.	223.0	63.7	527.	182.6	52.6	723.	250.5	68.9	23
126.4	40.2	10.8	122.4	38.9	10.5	24	122.1	38.9	10.5	121.3	38.6	10.4	709.	225.6	66.8	581.	184.9	55.2	793.	252.5	72.2	24
137.5	40.3	11.3	133.0	39.0	10.9	25	132.8	39.0	10.9	131.9	38.7	10.8	777.	227.9	69.8	637.	186.9	57.8	867.	254.4	75.4	25
148.9	40.4	11.7	144.2	39.1	11.3	26	144.0	39.0	11.3	142.9	38.8	11.3	848.	230.1	72.9	696.	188.9	60.4	944.	256.0	78.6	26
160.9	40.5	12.2	155.7	39.2	11.8	27	155.5	39.1	11.8	154.4	38.8	11.7	923.	232.1	75.9	758.	190.7	63.1	1024.	257.6	81.8	27
173.3	40.5	12.6	167.7	39.2	12.2	28	167.5	39.2	12.2	166.3	38.9	12.1	1000.	233.9	78.9	822.	192.3	65.7	1107.	259.0	84.9	28
186.1	40.6	13.1	180.1	39.3	12.6	29	179.9	39.2	12.7	178.7	39.0	12.6	1080.	235.5	81.9	889.	193.9	68.3	1194.	260.3	88.1	29
199.4	40.6	13.5	193.0	39.3	13.1	30	192.8	39.3	13.1	191.5	39.0	13.0	1164.	237.1	84.8	959.	195.3	70.8	1284.	261.5	91.3	30
213.1	40.7	14.0	206.3	39.4	13.5	31	206.1	39.3	13.5	204.7	39.0	13.4	1250.	238.5	87.7	1031.	196.7	73.4	1377.	262.6	94.5	31
227.3	40.7	14.4	220.0	39.4	14.0	32	219.9	39.4	14.0	218.3	39.1	13.9	1339.	239.8	90.7	1106.	198.0	76.0	1473.	263.7	97.6	32
242.0	40.7	14.9	234.2	39.4	14.4	33	234.0	39.4	14.4	232.4	39.1	14.3	1431.	241.0	93.5	1183.	199.2	78.5	1572.	264.6	100.7	33
257.1	40.8	15.3	248.8	39.5	14.8	34	248.6	39.4	14.8	246.9	39.2	14.7	1526.	242.1	96.4	1263.	200.3	81.1	1674.	265.5	103.9	34
272.6	40.8	15.8	263.9	39.5	15.3	35	263.7	39.5	15.3	261.8	39.2	15.2	1624.	243.1	99.1	1345.	201.3	83.7	1779.	266.3	106.9	35

Table 10. Example of a tarif access table (Source: *Tree-Volume Tarif Access Tables for Pacific Northwest Species*, vol. 2, State of Washington, Department of Natural Resources, June 1972)

DBH	TOTAL HEIGHT (FEET)																																		PAGE 5 OF 18
	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	122	124	126	128	130	132	134	136	138	140	142	144	146	148	150	152	154	156	158
12.0	35.8	36.6	37.4	38.3	39.1	39.9	40.8	41.6	42.4	43.2	44.1	44.9	45.7	46.5	47.3	48.2	49.0	49.8	50.6	51.4	52.2	53.0	53.8	54.6	55.4	56.2	57.0	57.8	58.6	59.4	60.2	61.0	61.7	62.5	63.3
12.1	35.6	36.5	37.3	38.1	39.0	39.8	40.6	41.5	42.3	43.1	43.9	44.7	45.6	46.4	47.2	48.0	48.8	49.6	50.4	51.2	52.0	52.8	53.6	54.4	55.2	56.0	56.8	57.6	58.4	59.2	60.0	60.8	61.6	62.3	63.1
12.2	35.5	36.4	37.2	38.0	38.9	39.7	40.5	41.3	42.1	43.0	43.8	44.6	45.4	46.2	47.0	47.9	48.7	49.5	50.3	51.1	51.9	52.7	53.5	54.3	55.1	55.9	56.7	57.4	58.2	59.0	59.8	60.6	61.4	62.2	62.9
12.3	35.4	36.3	37.1	37.9	38.7	39.6	40.4	41.2	42.0	42.8	43.7	44.5	45.3	46.1	46.9	47.7	48.5	49.3	50.1	50.9	51.7	52.5	53.3	54.1	54.9	55.7	56.5	57.3	58.1	58.8	59.6	60.4	61.2	62.0	62.7
12.4	35.3	36.1	37.0	37.8	38.6	39.4	40.3	41.1	41.9	42.7	43.5	44.3	45.1	46.0	46.8	47.6	48.4	49.2	50.0	50.8	51.6	52.4	53.2	54.0	54.7	55.5	56.3	57.1	57.9	58.7	59.5	60.2	61.0	61.8	62.6
12.5	35.2	36.0	36.9	37.7	38.5	39.3	40.1	41.0	41.8	42.6	43.4	44.2	45.0	45.8	46.6	47.4	48.2	49.0	49.8	50.6	51.4	52.2	53.0	53.8	54.6	55.4	56.2	56.9	57.7	58.5	59.3	60.1	60.8	61.6	62.4
12.6	35.1	35.9	36.7	37.6	38.4	39.2	40.0	40.8	41.6	42.5	43.3	44.1	44.9	45.7	46.5	47.3	48.1	48.9	49.7	50.5	51.3	52.1	52.8	53.6	54.4	55.2	56.0	56.8	57.5	58.3	59.1	59.9	60.7	61.4	62.2
12.7	35.0	35.8	36.6	37.5	38.3	39.1	39.9	40.7	41.5	42.3	43.1	43.9	44.7	45.5	46.3	47.1	47.9	48.7	49.5	50.3	51.1	51.9	52.7	53.5	54.3	55.0	55.8	56.6	57.4	58.2	58.9	59.7	60.5	61.2	62.0
12.8	34.9	35.7	36.5	37.3	38.2	39.0	39.8	40.6	41.4	42.2	43.0	43.8	44.6	45.4	46.2	47.0	47.8	48.6	49.4	50.2	51.0	51.8	52.5	53.3	54.1	54.9	55.7	56.4	57.2	58.0	58.8	59.5	60.3	61.1	61.9
12.9	34.8	35.6	36.4	37.2	38.0	38.9	39.7	40.5	41.3	42.1	42.9	43.7	44.5	45.3	46.1	46.9	47.7	48.5	49.2	50.0	50.8	51.6	52.4	53.2	54.0	54.7	55.5	56.3	57.1	57.8	58.6	59.4	60.1	60.9	61.7
13.0	34.7	35.5	36.3	37.1	37.9	38.7	39.6	40.4	41.2	42.0	42.8	43.6	44.4	45.2	45.9	46.7	47.5	48.3	49.1	49.9	50.7	51.5	52.2	53.0	53.8	54.6	55.4	56.1	56.9	57.7	58.4	59.2	60.0	60.7	61.5
13.1	34.6	35.4	36.2	37.0	37.8	38.6	39.4	40.2	41.0	41.8	42.6	43.4	44.2	45.0	45.8	46.6	47.4	48.2	49.0	49.8	50.5	51.3	52.1	52.9	53.6	54.4	55.2	56.0	56.7	57.5	58.3	59.0	59.8	60.6	61.3
13.2	34.5	35.3	36.1	36.9	37.7	38.5	39.3	40.1	40.9	41.7	42.5	43.3	44.1	44.9	45.7	46.5	47.3	48.1	48.8	49.6	50.4	51.2	52.0	52.7	53.5	54.3	55.0	55.8	56.6	57.3	58.1	58.9	59.6	60.4	61.1
13.3	34.4	35.2	36.0	36.8	37.6	38.4	39.2	40.0	40.8	41.6	42.4	43.2	44.0	44.8	45.6	46.3	47.1	47.9	48.7	49.5	50.3	51.0	51.8	52.6	53.4	54.1	54.9	55.7	56.4	57.2	57.9	58.7	59.5	60.2	61.0
13.4	34.3	35.1	35.9	36.7	37.5	38.3	39.1	39.9	40.7	41.5	42.3	43.1	43.9	44.7	45.4	46.2	47.0	47.8	48.6	49.3	50.1	50.9	51.7	52.4	53.2	54.0	54.7	55.5	56.3	57.0	57.8	58.6	59.3	60.1	60.8
13.5	34.2	35.0	35.8	36.6	37.4	38.2	39.0	39.8	40.6	41.4	42.2	43.0	43.7	44.5	45.3	46.1	46.9	47.7	48.4	49.2	50.0	50.8	51.5	52.3	53.1	53.8	54.6	55.4	56.1	56.9	57.6	58.4	59.1	59.9	60.7
13.6	34.1	34.9	35.7	36.5	37.3	38.1	38.9	39.7	40.5	41.3	42.1	42.8	43.6	44.4	45.2	46.0	46.7	47.5	48.3	49.1	49.8	50.6	51.4	52.2	52.9	53.7	54.4	55.2	56.0	56.7	57.5	58.2	59.0	59.7	60.5
13.7	34.0	34.8	35.6	36.4	37.2	38.0	38.8	39.6	40.4	41.2	41.9	42.7	43.5	44.3	45.1	45.8	46.6	47.4	48.2	48.9	49.7	50.5	51.3	52.0	52.8	53.5	54.3	55.1	55.8	56.6	57.3	58.1	58.8	59.6	60.3
13.8	33.9	34.7	35.5	36.3	37.1	37.9	38.7	39.5	40.3	41.0	41.8	42.6	43.4	44.2	44.9	45.7	46.5	47.3	48.0	48.8	49.6	50.3	51.1	51.9	52.6	53.4	54.2	54.9	55.7	56.4	57.2	57.9	58.7	59.4	60.2
13.9	33.8	34.6	35.4	36.2	37.0	37.8	38.6	39.4	40.2	40.9	41.7	42.5	43.3	44.1	44.8	45.6	46.4	47.1	47.9	48.7	49.5	50.2	51.0	51.7	52.5	53.3	54.0	54.8	55.5	56.3	57.0	57.8	58.5	59.3	60.0
14.0	33.7	34.5	35.3	36.1	36.9	37.7	38.5	39.3	40.0	40.8	41.6	42.4	43.2	43.9	44.7	45.5	46.3	47.0	47.8	48.6	49.3	50.1	50.8	51.6	52.4	53.1	53.9	54.6	55.4	56.1	56.9	57.6	58.4	59.1	59.9
14.1	33.7	34.4	35.2	36.0	36.8	37.6	38.4	39.2	39.9	40.7	41.5	42.3	43.1	43.8	44.6	45.4	46.1	46.9	47.7	48.4	49.2	50.0	50.7	51.5	52.2	53.0	53.7	54.5	55.2	56.0	56.7	57.5	58.2	59.0	59.7
14.2	33.6	34.4	35.1	35.9	36.7	37.5	38.3	39.1	39.8	40.6	41.4	42.2	42.9	43.7	44.5	45.2	46.0	46.8	47.5	48.3	49.1	49.8	50.6	51.3	52.1	52.9	53.6	54.4	55.1	55.8	56.6	57.3	58.1	58.8	59.6
14.3	33.5	34.3	35.1	35.8	36.6	37.4	38.2	39.0	39.7	40.5	41.3	42.1	42.8	43.6	44.4	45.1	45.9	46.7	47.4	48.2	48.9	49.7	50.5	51.2	52.0	52.7	53.5	54.2	55.0	55.7	56.4	57.2	57.9	58.7	59.4
14.4	33.4	34.2	35.0	35.7	36.5	37.3	38.1	38.9	39.6	40.4	41.2	42.0	42.7	43.5	44.3	45.0	45.8	46.5	47.3	48.1	48.8	49.6	50.3	51.1	51.8	52.6	53.3	54.1	54.8	55.6	56.3	57.0	57.8	58.5	59.3
14.5	33.3	34.1	34.9	35.7	36.4	37.2	38.0	38.8	39.5	40.3	41.1	41.8	42.6	43.4	44.1	44.9	45.7	46.4	47.2	47.9	48.7	49.5	50.2	51.0	51.7	52.5	53.2	53.9	54.7	55.4	56.2	56.9	57.6	58.4	59.1
14.6	33.2	34.0	34.8	35.6	36.3	37.1	37.9	38.7	39.4	40.2	41.0	41.7	42.5	43.3	44.0	44.8	45.6	46.3	47.1	47.8	48.6	49.3	50.1	50.8	51.6	52.3	53.1	53.8	54.6	55.3	56.0	56.8	57.5	58.2	59.0
14.7	33.1	33.9	34.7	35.5	36.2	37.0	37.8	38.6	39.3	40.1	40.9	41.6	42.4	43.2	43.9	44.7	45.4	46.2	47.0	47.7	48.5	49.2	50.0	50.7	51.4	52.2	52.9	53.7	54.4	55.2	55.9	56.6	57.4	58.1	58.8
14.8	33.1	33.8	34.6	35.4	36.2	36.9	37.7	38.5	39.2	40.0	40.8	41.5	42.3	43.1	43.8	44.6	45.3	46.1	46.8	47.6	48.3	49.1	49.8	50.6	51.3	52.1	52.8	53.5	54.3	55.0	55.8	56.5	57.2	58.0	58.7
14.9	33.0	33.7	34.5	35.3	36.1	36.8	37.6	38.4	39.1	39.9	40.7	41.4	42.2	43.0	43.7	44.5	45.2	46.0	46.7	47.5	48.2	49.0	49.7	50.5	51.2	51.9	52.7	53.4	54.2	54.9	55.6	56.4	57.1	57.8	58.5
15.0	32.9	33.7	34.4	35.2	36.0	36.7	37.5	38.3	39.0	39.8	40.6	41.3	42.1	42.8	43.6	44.4	45.1	45.9	46.6	47.4	48.1	48.9	49.6	50.3	51.1	51.8	52.6	53.3	54.0	54.8	55.5	56.2	56.9	57.7	58.4
15.1	32.8	33.6	34.4	35.1	35.9	36.7	37.4	38.2	39.0	39.7	40.5	41.2	42.0	42.7	43.5	44.2	45.0	45.8	46.5	47.2	48.0	48.7	49.5	50.2	51.0	51.7	52.4	53.2	53.9	54.6	55.4	56.1	56.8	57.5	58.3
15.2	32.7	33.5	34.3	35.0	35.8	36.6	37.3	30.1	38.9	39.6	40.4	41.1	41.9	42.6	43.4	44.1	44.9	45.6	46.4	47.1	47.9	48.6	49.4	50.1	50.8	51.6	52.3	53.0	53.8	54.5	55.2	56.0	56.7	57.4	58.1
15.3	32.7	33.4	34.2	35.0	35.7	36.5	37.2	38.0	38.8	39.5	40.3	41.0	41.8	42.5	43.3	44.0	44.8	45.5	46.3	47.0	47.8	48.5	49.2	50.0	50.7	51.4	52.2	52.9	53.6	54.4	55.1	55.8	56.5	57.3	58.0
15.4	32.6	33.3	34.1	34.9	35.6	36.4	37.2	37.9	38.7	39.4	40.2	40.9	41.7	42.4	43.2	43.9	44.7	45.4	46.2	46.9	47.7	48.4	49.1	49.9	50.6	51.3	52.1	52.8	53.5	54.2	55.0	55.7	56.4	57.1	57.9
15.5	32.5	33.3	34.0	34.8	35.5	36.3	37.1	37.8	38.6	39.3	40.1	40.8	41.6	42.3	43.1	43.8	44.6	45.3	46.1	46.8	47.5	48.3	49.0	49.7	50.5	51.2	51.9	52.7	53.4	54.1	54.9	55.6	56.3	57.0	57.7
15.6	32.4	33.2	33.9	34.7	35.5	36.2	37.0	37.7	38.5	39.2	40.0	40.7	41.5	42.2	43.0	43.7	44.5	45.2	46.0	46.7	47.4	48.2	48.9	49.6	50.4	51.1	51.8	52.5	53.3	54.0	54.7	55.4	56.2	56.9	57.6
15.7	32.3	33.1	33.9	34.6	35.4	36.1	36.9	37.6	38.4	39.2	39.9	40.7	41.4	42.1	42.9	43.6	44.4	45.1	45.8	46.6	47.3	48.1	48.8	49.5	50.2	51.0	51.7	52.4	53.2	53.9	54.6	55.3	56.0	56.7	57.5
15.8	32.3	33.0	33.8	34.5	35.3	36.1	36.8	37.6	38.3	39.1	39.8	40.6	41.3	42.0	42.8	43.5	44.3	45.0	45.7	46.5	47.2	47.9	48.7	49.4	50.1	50.9	51.6	52.3	53.0	53.8	54.5	55.2	55.9	56.6	57.3
15.9	32.2	33.0	33.7	34.5	35.2	36.0	36.7	37.5	38.2	39.0	39.7	40.5	41.2	42.0	42.7	43.4	44.2	44.9	45.6	46.4	47.1	47.8	48.6	49.3	50.0	50.7	51.5	52.2	52.9	53.6	54.3	55.1	55.8	56.5	57.2
16.0	32.1	32.9	33.6	34.4	35.1	35.9	36.6	37.4	38.1	38.9	39.6	40.4	41.1	41.9	42.6	43.3	44.1	44.8	45.5	46.3	47.0	47.7	48.5	49.2	49.9	50.6	51.4	52.1	52.8	53.5	54.2	54.9	55.7	56.4	57.1
16.1	32.0	32.8	33.6	34.3	35.1	35.8	36.6	37.3	38.1	38.8	39.5	40.3	41.0	41.8	42.5	43.2	44.0	44.7	45.4	46.2	46.9	47.6	48.3	49.1	49.8	50.5	51.2	52.0	52.7	53.4	54.1	54.8	55.5	56.2	56.9
16.2	32.0	32.7	33.5	34.2	35.0	35.7	36.5	37.2	38.0	38.7	39.5	40.2	40.9	41.7	42.4	43.1	43.9	44.6	45.3	46.1	46.8	47.5	48.2	49.0	49.7	50.4	51.1	51.8	52.6	53.3	54.0	54.7	55.4	56.1	56.8
16.3	31.9	32.7	33.4	34.2	34.9	35.6	36.4	37.1	37.9	38.6	39.4	40.1	40.8	41.6	42.3	43.0	43.8	44.5	45.2	46.0	46.7	47.4	48.1	48.9	49.6	50.3	51.0	51.7	52.4	53.2	53.9	54.6	55.3	56.0	56.7
16.4	31.8	32.6	33.3	34.1	34.8	35.6	36.3	37.1	37.8	38.5	39.3	40.0	40.8	41.5	42.2	42.9	43.7	44.4	45.1	45.9	46.6	47.3	48.0	48.8	49.5	50.2	50.9	51.6	52.3	53.0	53.8	54.5	55.2	55.9	56.6
16.5	31.8	32.5	33.3	34.0	34.7	35.5	36.2	37.0	37.7	38.5	39.2	39.9	40.7	41.4	42.1	42.9	43.6	44.3	45.0	45.8	46.5	47.2	47.9	48.6	49.4	50.1	50.8	51.5	52.2	52.9	53.6	54.3	55.0	55.8	56.5
16.6	31.7	32.4	33.2	33.9	34.7	35.4	36.2	36.9	37.6	38.4	39.1	39.8	40.6	41.3	42.0	42.8	43.5	44.2	44.9	45.7	46.4	47.1	47.8	48.5	49.3	50.0	50.7	51.4	52.1	52.8	53.5	54.2	54.9	55.6	56.3
16.7	31.6	32.4	33.1	33.9	34.6	35.3	36.1	36.8	37.6	38.3	39.0	39.8	40.5	41.2	41.9	42.7	43.4	44.1	44.8	45.6	46.3	47.0	47.7	48.4	49.2	49.9	50.6	51.3	52.0	52.7	53.4	54.1	54.8	55.5	56.2
16.8	31.6	32.3	33.0	33.8	34.5	35.3	36.0	36.7	37.5	38.2	38.9	39.7	40.4	41.1	41.9	42.6	43.3	44.0	44.7	45.5	46.2	46.9	47.6	48.3	49.0	49.8	50.5	51.2	51.9	52.6	53.3	54.0	54.7	55.4	56.1
16.9	31.5	32.2	33.0	33.7	34.4	35.2	35.9	36.7	37.4	38.1	38.9	39.6	40.3	41.0	41.8	42.5	43.2	43.9	44.7	45.4	46.1	46.8	47.5	48.2	48.9	49.7	50.4	51.1	51.8	52.5	53.2	53.9	54.6	55.3	56.0
17.0	31.4	32.2	32.9	33.6	34.4	35.1	35.8	36.6	37.3	38.0	38.8	39.5	40.2	41.0	41.7	42.4	43.1	43.8	44.6	45.3	46.0	46.7	47.4	48.1	48.8	49.6	50.3	51.0	51.7	52.4	53.1	53.8	54.5	55.2	55.9
17.1	31.3	32.1	32.8	33.6	34.3	35.0	35.8	36.5	37.2	38.0	38.7	39.4	40.1	40.9	41.6	42.3	43.0	43.7	44.5	45.2	45.9	46.6	47.3	48.0	48.7	49.4	50.2	50.9	51.6	52.3	53.0	53.7	54.4	55.1	55.7
17.2	31.3	32.0	32.8	33.5	34.2	35.0	35.7	36.4	37.2	37.9	38.6	39.3	40.1	40.8	41.5	42.2	42.9	43.7	44.4	45.1	45.8	46.5	47.2	47.9	48.6	49.3	50.0	50.8	51.5	52.2	52.9	53.6	54.2	54.9	55.6
17.3	31.2	32.0	32.7	33.4	34.2	34.9	35.6	36.3	37.1	37.8	38.5	39.3	40.0	40.7	41.4	42.1	42.9	43.6	44.3	45.0	45.7	46.4	47.1	47.8	48.5	49.2	49.9	50.6	51.3	52.0	52.7	53.4	54.1	54.8	55.5
17.4	31.2	31.9	32.6	33.4	34.1	34.8	35.5	36.3	37.0	37.7	38.4	39.2	39.9	40.6	41.3	42.0	42.8	43.5	44.2	44.9	45.6	46.3	47.0	47.7	48.4	49.1	49.8	50.5	51.2	51.9	52.6	53.3	54.0	54.7	55.4
17.5	31.1	31.8	32.6	33.3	34.0	34.7	35.5	36.2	36.9	37.6	38.4	39.1	39.8	40.5	41.2	42.0	42.7	43.4	44.1	44.8	45.5	46.2	46.9	47.6	48.3	49.0	49.7	50.4	51.1	51.8	52.5	53.2	53.9	54.6	55.3
17.6	31.0	31.8	32.5	33.2	33.9	34.7	35.4	36.1	36.8	37.6	38.3	39.0	39.7	40.4	41.2	41.9	42.6	43.3	44.0	44.7	45.4	46.1	46.8	47.5	48.2	48.9	49.6	50.3	51.0	51.7	52.4	53.1	53.8	54.5	55.2
17.7	31.0	31.7	32.4	33.1	33.9	34.6	35.3	36.0	36.8	37.5	38.2	38.9	39.6	40.4	41.1	41.8	42.5	43.2	43.9	44.6	45.3	46.0	46.7	47.4	48.1	48.8	49.5	50.2	50.9	51.6	52.3	53.0	53.7	54.4	55.1
17.8	30.9	31.6	32.4	33.1	33.8	34.5	35.3	36.0	36.7	37.4	38.1	38.9	39.6	40.3	41.0	41.7	42.4	43.1	43.8	44.5	45.2	45.9	46.6	47.4	48.0	48.7	49.4	50.1	50.8	51.5	52.2	52.9	53.6	54.3	55.0
17.9	30.8	31.6	32.3	33.0	33.7	34.5	35.2	35.9	36.6	37.3	38.1	38.8	39.5	40.2	40.9	41.6	42.3	43.0	43.7	44.5	45.2	45.9	46.6	47.3	48.0	48.7	49.2	50.0	50.7	51.4	52.1	52.8	53.5	54.2	54.9
18.0	30.8	31.5	32.2	32.9	33.7	34.4	35.1	35.8	36.5	37.3	38.0	38.7	39.4	40.1	40.8	41.5	42.2	43.0	43.7	44.4	45.1	45.8	46.5	47.2	47.9	48.6	49.2	49.9	50.6	51.3	52.0	52.7	53.4	54.1	54.8
18.1	30.7	31.4	32.2	32.9	33.6	34.3	35.0	35.8	36.5	37.2	37.9	38.6	39.3	40.0	40.7	41.5	42.2	42.9	43.6	44.3	45.0	45.7	46.4	47.1	47.8	48.5	49.2	49.8	50.5	51.2	51.9	52.6	53.3	54.0	54.6
18.2	30.6	31.4	32.1	32.8	33.5	34.3	35.0	35.7	36.4	37.1	37.8	38.5	39.3	40.0	40.7	41.4	42.1	42.8	43.5	44.2	44.9	45.6	46.3	47.0	47.7	48.4	49.1	49.7	50.4	51.1	51.8	52.5	53.2	53.9	54.5
18.3	30.6	31.3	32.0	32.7	33.5	34.2	34.9	35.6	36.3	37.0	37.8	38.5	39.2	39.9	40.6	41.3	42.0	42.7	43.4	44.1	44.8	45.5	46.2	46.9	47.6	48.3	49.0	49.7	50.3	51.0	51.7	52.4	53.1	53.8	54.4
18.4	30.5	31.2	32.0	32.7	33.4	34.1	34.8	35.5	36.3	37.0	37.7	38.4	39.1	39.8	40.5	41.2	41.9	42.6	43.3	44.0	44.7	45.4	46.1	46.8	47.5	48.2	48.9	49.6	50.2	50.9	51.6	52.3	53.0	53.7	54.3
18.5	30.5	31.2	31.9	32.6	33.3	34.1	34.8	35.5	36.2	36.9	37.6	38.3	39.0	39.7	40.4	41.1	41.8	42.5	43.2	43.9	44.6	45.3	46.0	46.7	47.4	48.1	48.8	49.5	50.1	50.8	51.5	52.2	52.9	53.5	54.2
18.6	30.4	31.1	31.8	32.6	33.3	34.0	34.7	35.4	36.1	36.8	37.5	38.2	38.9	39.7	40.4	41.1	41.8	42.5	43.2	43.8	44.5	45.2	45.9	46.6	47.3	48.0	48.7	49.4	50.0	50.7	51.4	52.1	52.8	53.4	54.1
18.7	30.3	31.1	31.8	32.5	33.2	33.9	34.6	35.3	36.0	36.8	37.5	38.2	38.9	39.6	40.3	41.0	41.7	42.4	43.1	43.8	44.5	45.1	45.8	46.5	47.2	47.9	48.6	49.3	50.0	50.6	51.3	52.0	52.7	53.3	54.0
18.8	30.3	31.0	31.7	32.4	33.1	33.9	34.6	35.3	36.0	36.7	37.4	38.1	38.8	39.5	40.2	40.9	41.6	42.3	43.0	43.7	44.4	45.1	45.8	46.4	47.1	47.8	48.5	49.2	49.9	50.5	51.2	51.9	52.6	53.2	53.9
18.9	30.2	30.9	31.7	32.4	33.1	33.8	34.5	35.2	35.9	36.6	37.3	38.0	38.7	39.4	40.1	40.8	41.5	42.2	42.9	43.6	44.3	45.0	45.7	46.4	47.0	47.7	48.4	49.1	49.8	50.4	51.1	51.8	52.5	53.1	53.8
19.0	30.2	30.9	31.6	32.3	33.0	33.7	34.4	35.1	35.8	36.5	37.3	38.0	38.7	39.4	40.0	40.7	41.4	42.1	42.8	43.5	44.2	44.9	45.6	46.3	47.0	47.6	48.3	49.0	49.7	50.4	51.0	51.7	52.4	53.0	53.7
19.1	30.1	30.8	31.5	32.2	33.0	33.7	34.4	35.1	35.8	36.5	37.2	37.9	38.6	39.3	40.0	40.7	41.4	42.1	42.7	43.4	44.1	44.8	45.5	46.2	46.9	47.5	48.2	48.9	49.6	50.3	50.9	51.6	52.3	53.0	53.6
19.2	30.1	30.8	31.5	32.2	32.9	33.6	34.3	35.0	35.7	36.4	37.1	37.8	38.5	39.2	39.9	40.6	41.3	42.0	42.7	43.4	44.0	44.7	45.4	46.1	46.8	47.5	48.1	48.8	49.5	50.2	50.8	51.5	52.2	52.9	53.5
19.3	30.0	30.7	31.4	32.1	32.8	33.5	34.2	34.9	35.6	36.3	37.0	37.7	38.4	39.1	39.8	40.5	41.2	41.9	42.6	43.3	44.0	44.6	45.3	46.0	46.7	47.4	48.0	48.7	49.4	50.1	50.7	51.4	52.1	52.8	53.4
19.4	29.9	30.6	31.4	32.1	32.8	33.5	34.2	34.9	35.6	36.3	37.0	37.7	38.4	39.1	39.8	40.4	41.1	41.8	42.5	43.2	43.9	44.6	45.2	45.9	46.6	47.3	48.0	48.6	49.3	50.0	50.7	51.3	52.0	52.7	53.3
19.5	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.8	35.5	36.2	36.9	37.6	38.3	39.0	39.7	40.4	41.1	41.7	42.4	43.1	43.8	44.5	45.2	45.8	46.5	47.2	47.9	48.5	49.2	49.9	50.6	51.2	51.9	52.6	53.2
19.6	29.8	30.5	31.2	31.9	32.6	33.3	34.0	34.7	35.4	36.1	36.8	37.5	38.2	38.9	39.6	40.3	41.0	41.7	42.4	43.0	43.7	44.4	45.1	45.8	46.4	47.1	47.8	48.5	49.1	49.8	50.5	51.1	51.8	52.5	53.1
19.7	29.8	30.5	31.2	31.9	32.6	33.3	34.0	34.7	35.4	36.1	36.8	37.5	38.2	38.8	39.5	40.2	40.9	41.6	42.3	43.0	43.6	44.3	45.0	45.7	46.4	47.0	47.7	48.4	49.0	49.7	50.4	51.0	51.7	52.4	53.0
19.8	29.7	30.4	31.1	31.8	32.5	33.2	33.9	34.6	35.3	36.0	36.7	37.4	38.1	38.8	39.5	40.1	40.8	41.5	42.2	42.9	43.6	44.2	44.9	45.6	46.3	46.9	47.6	48.3	49.0	49.6	50.3	51.0	51.6	52.3	52.9
19.9	29.7	30.4	31.1	31.8	32.5	33.2	33.9	34.6	35.3	35.9	36.6	37.3	38.0	38.7	39.4	40.1	40.8	41.4	42.1	42.8	43.5	44.2	44.8	45.5	46.2	46.9	47.5	48.2	48.9	49.5	50.2	50.9	51.5	52.2	52.9

Measuring volume of standing trees

To estimate the volume of an individual tree, choose one of the four types of tables previously mentioned: (1) measure the diameter at breast height outside bark (DHB); (2) determine the tree height (unless you are using a local or tarif volume table); and (3) refer to the appropriate volume table. Breast height is assumed to be a point 4½ feet above the average ground line on the level or a moderate slope. On steep ground, take DBH 4½ feet above the ground on the uphill side of the tree. Tally DBH to the nearest inch or even-numbered inch, depending on the volume table used. Tree height may be measured to the tip of the tree or to some diameter which is specified by the table being used. Height may be expressed in number of logs or in feet. For example, table 6 is in number of 16-foot logs to an 8-inch top diameter inside bark while table 5 is in total height expressed in feet.

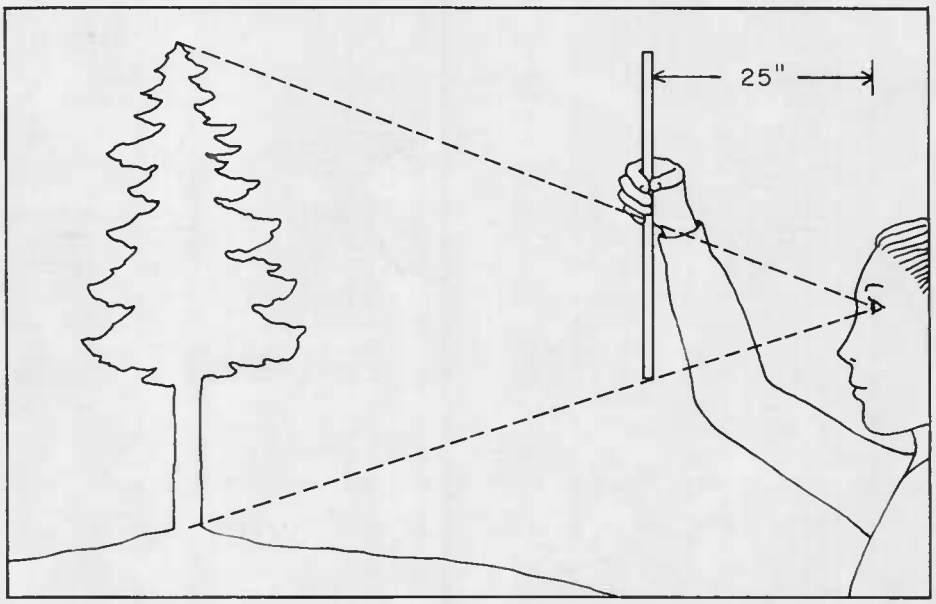

Figure 2. Measuring tree height with the Biltmore cruiser stick

Approximating heights and diameters with the Biltmore stick (cruiser stick)

In the past, woodland owners have used the Biltmore cruiser stick to measure both the diameters and heights of trees (see figures 2, 3, and 4). Cruiser sticks can be purchased from forestry supply houses. Although the stick can give you a good indication of diameter and height, it may be advantageous to use instruments that give more precise readings.

Remember these points in using a cruising stick for measuring height:

- Pace as accurately as possible the horizontal distance away from the tree (66 or 99 feet). Stand on the same level as the base of the tree—neither up nor downhill.
- Check the distance from your eye to the stick (should be 25 inches—see figure 2).
- Hold the stick straight up and down, in line with the trunk of the tree.
- Move your eyes, not your head, when reading from bottom to top of the stick.
- Know what minimum top diameter you want and estimate this point on the tree, then count the logs from the stump height to this point.

Make height measurements as specified for a particular table. For example, if you are using a table that has an upper diameter limit of 4 inches, measure all tree heights to the 4-inch top.

Figure 3. Measuring the number of logs in a tree with the Biltmore cruiser stick

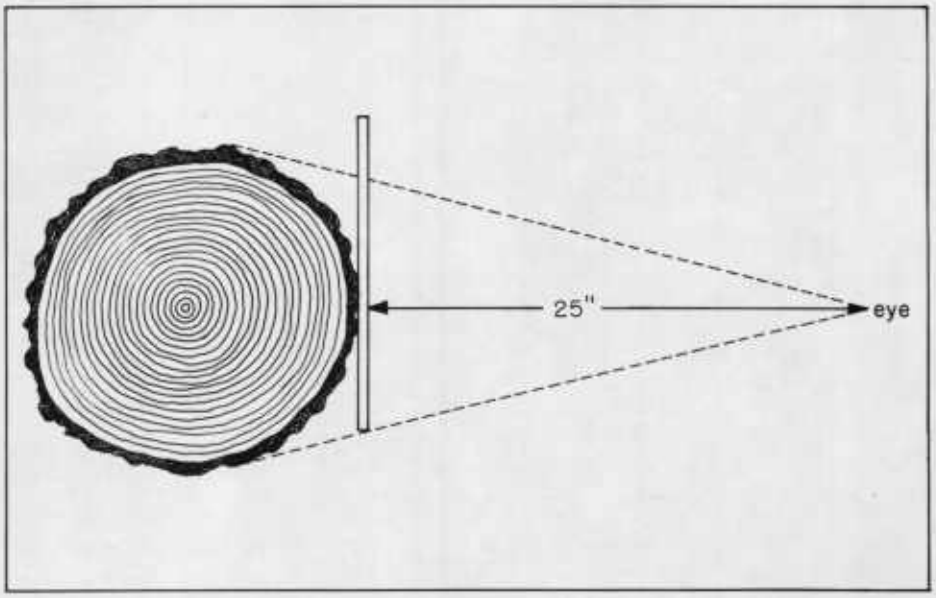

Figure 4. Measuring tree diameter with the Biltmore cruiser stick

Remember these points in using the cruising stick to measure diameters:

- Keep your eyes level with the stick.
- Check the distance from your eye to the stick (should be 25 inches).
- Determine diameter by holding the stick on the narrow side of the tree, then determine the diameter by holding the stick on the wide side of the tree. The average of these two measurements is the tree's diameter. Some cruisers hold the stick on the side of the tree where the average diameter can be measured.
- Move your eyes, not your head, when reading from one side to the other.
- Diameters are usually recorded to the nearest even inch.

Measuring diameters using the diameter tape

A diameter tape provides a way of measuring a tree's circumference and directly converting it to diameter (see figure 5). Readings are direct and accurate. The tape must be level all the way around the tree to avoid any abnormal diameter readings. If there are branch whorls or other projections from the bark at 4½ feet (DBH), put the measurement tape above them so the actual average diameter of the tree will be recorded. If you do not hold the tape level around the tree, your result will be an overestimate. Diameters are usually rounded to nearest inch or even-numbered inch, depending on the volume table used. You can use a normal tape to measure the circumference of the tree. Convert to diameter by the formula:

$$\text{DBH} = \frac{\text{circumference (inches)}}{3.14}$$

Measuring heights with an instrument

The Suunto clinometer is a convenient instrument for measuring tree heights. To use the clinometer as a vertical angle measurer, place the clinometer to one eye as indicated in figure 6 and move it up and down the tree stem until the horizontal index line, viewed through the lens, is aligned with the point of interest on the tree.

You simultaneoulsly look into the clinometer with one eye and alongside the clinometer with the other eye (you cannot see through the clinometer). By optical illusion the horizontal index line seems to protrude from the instrument body. You see this line against the tree. At the same time, you see the graduated scales. Thus in one simultaneous view, you see the tree and the index line and you read the desired scale. It is fast and accurate.

Figure 5. Measuring tree diameter with a tree diameter tape

For example, to measure tree height (see figures 6a, 6b, and 6c for three different situations that can occur in measuring a tree's height):

- Measure distance A-B in feet (this is a horizontal distance).
- Stand at point A.
- Read slope percent to base of tree (G-B), which is angle F.
- Read slope percent to tree top (G-D), which is angle E.
- Combine angles E and F by adding both percents if one percent is plus (+) and the other percent is minus (—) (figures 6a and 6b). If both percents are plus, subtract angle F percent from angle E percent (figure 6c). If both percents are plus, subtract angle F percent from angle E percent (figure 6c). If A-B is 100 feet as in figure 6a, the total tree height (B-D) is the same as the combined perent of angles E and F and is expressed in feet. Thus the total height of the tree in figure 6a is 80 feet.

In figure 6b, where the distance A-B is different than 100 feet, divide the distance A-B by 100 and multiply that figure by the percentage of the combined angles.

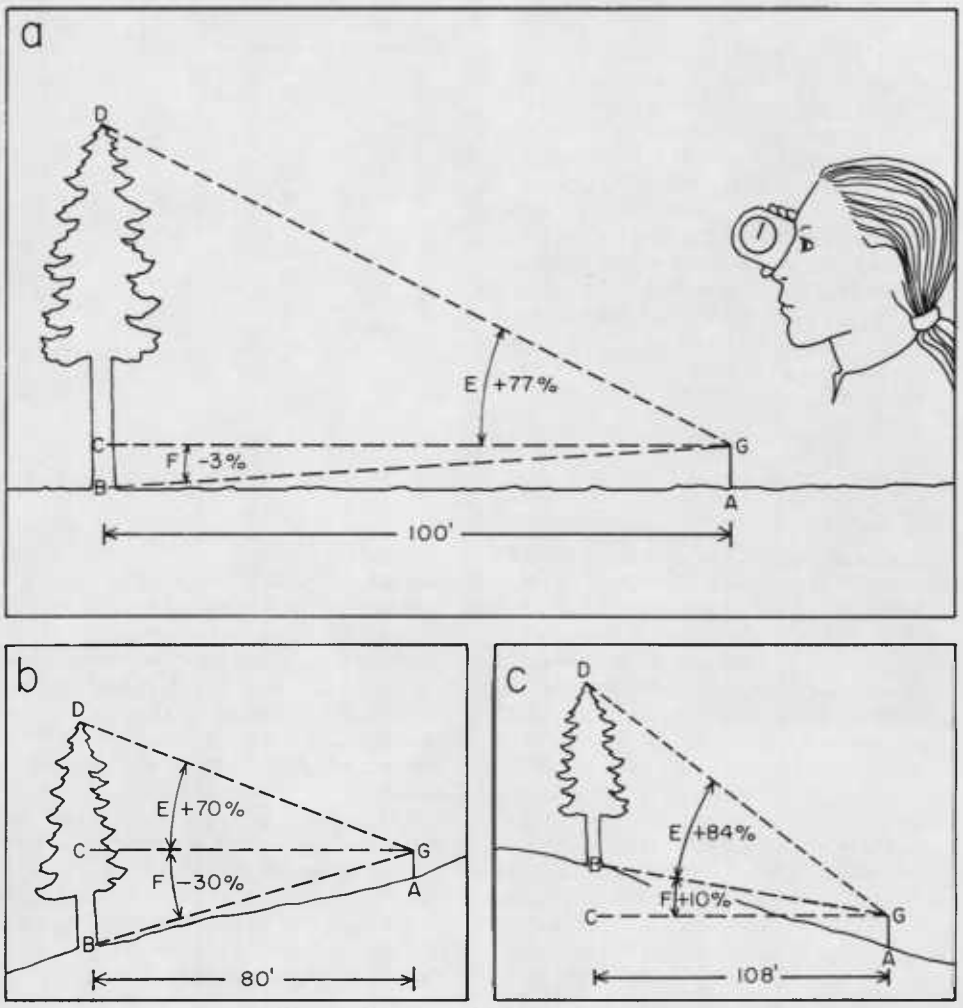

Figure 6. Measuring tree height with a clinometer

Examples:

A − B = 80
Angles E and F combined = 100
80 divided by 100 = .80
Total tree height is .8 times 100 or 80 feet

In figure 6c the calculations follow the same procedure as in figure 6b.

A − B = 108
Angles E and F combined = 74
108 divided by 100 = 1.08
Total tree height is 1.08 times 74 or 80 feet

Log grading

In order to determine the value of a stand, you must assess the quality as well as the quantity of wood. This is called "grading." In assigning a grade to a log in a tree, the cruiser considers the log diameter, the number, size and spacing of knots, and a minimum number of annual rings per inch. The log grades by species can be found in a rule book published by the Northwest Log Rule Advisory Group, available from major log-scaling bureaus throughout the Northwest.

Tables 11 and 12 are useful in estimating the volume of wood by log grade in a tree when using form class or tarif volume tables. An example is a tree 20" DBH that has 2½ 32 foot logs and contains 459 board feet. The first log is graded as a number 2 saw log and the remaining 1½ logs are number 3 saw log. As shown in table 11, the first log in a 2½-log tree has 62 percent of the tree's volume, the second log has 28 percent, and the top ½ log contains 10 percent. Thus, 62 percent of the tree's volume (285) is number 2 saw log and the remaining 38 percent (174) is number 3 saw log.

Table 11. Percentage of tree volume in 16-foot logs (for Girard form-class tables, top d.i.b. equal to 50 percent of d.i.b. first log)

Number of 16-foot logs in tree	Log position (above stump)										
	1st %	2nd %	3rd %	4th %	5th %	6th %	7th %	8th %	9th %	10th %	11th %
1 log	100										
2 logs	85	15									
3 logs	55	35	10								
4 logs	41	31	20	8							
5 logs	32	27	21	14	6						
6 logs	27	23	19	15	11	5					
7 logs	23	20	17	15	12	8	5				
8 logs	20	18	16	14	12	9	7	4			
9 logs	17	16	15	13	11	10	8	6	4		
10 logs	16	15	13	12	11	10	8	7	5	3	
11 logs	14	13	13	11	11	10	6	7	6	4	3

Table 12. Percentage of tree volume in 32-foot logs (for Girard form-class tables, top d.i.b. equal to 60 percent of d.i.b. first log)

Number of 32-foot logs in tree	Log position (above stump)										
	1st	1½	2nd	2½	3rd	3rd	3½	4th	4½	5th	5½	6th
1 log	100											
1½ logs	86	14										
2 logs	75		25									
2½ logs	62		28	10								
3 logs	50		33		17							
3½ logs	46		31		15	8						
4 logs	37		29		21		13					
4½ logs	37		28		19		10	6				
5 logs	30		25		20		15		10			
5½ logs	30		25		19		13		8	5		
6 logs	25		22		18		15		12			8

Deduct for defect

Not all trees on a woodland property will be completely usable. Some trees will be excessively rough or partly rotted. Some are of such poor quality they are completely unsaleable. You must determine the amount of defect and reduce the saleable volume accordingly. Experienced timber cruisers use external indicators such as scars, bark characteristics, and conks to help them estimate the quantity and quality of standing trees.

Many second-growth woodlands will contain old-growth snags or windfalls that have some merchantable volume. The outside appearance of these snags or logs is deceiving. To determine the inside quality, it is necessary either to chop into them at several spots or to fell and buck them. The sapwood may be entirely rotted away while the inside heartwood is perfectly sound and bright in color. It takes considerable experience to recognize and make proper allowance for defective material in trees.

On steep ground it is almost impossible to prevent breaking some trees during felling. With careful felling, breakage will be minimized. If you are determining the volume to an 8-inch top, on steep ground, deduct 5 to 10 percent of the volume for breakage. Breakage is not as serious in young timber as it is in old-growth timber.

You can use tables 11 and 12 in conjunction with form class or tarif volume tables as an aid in estimating the volume lost because of defect in the same manner that you determine volume by grade.

Sampling a forest stand

The simplest way to obtain the approximate volume of a forest stand is to measure a sample (portion) of that stand. A sample is composed of a number of plots on which measurements of individual trees are tallied. These plots usually are evenly spaced over the stand along compass lines to get a good estimate of the volume per acre. Compass lines are established across drainages so that there will be a sampling of the timber near creeks, on the slopes, and on the ridgetops. Figure 7 is an example of a 10-percent sample of a 40-acre stand using 1/5-acre plots.

Fixed-plot sampling

Fixed plots have a given size. They may be square, rectangular, or circular. They usually are circular in shape. The more frequently used plot sizes for small or dense timber are 1/10- or 1/20-acre plot. A 1/5-acre plot is most common for sawtimber. Table 12 gives the radius of various sized circular plots. The diameter, height (if needed), grade (for each log in the tree), and defects are recorded for each tree on the plot.

It is important to select the appropriate volume table in order to know what measurements to record for the trees on the sample plots. After you make the measurements, obtain the volume for each tree from the selected volume table. Calculate the total volume by multiplying the average volume per plot times the number of plots per acre (five, for example, if 1/5-acre plots are used) times the number of acres in the stand.

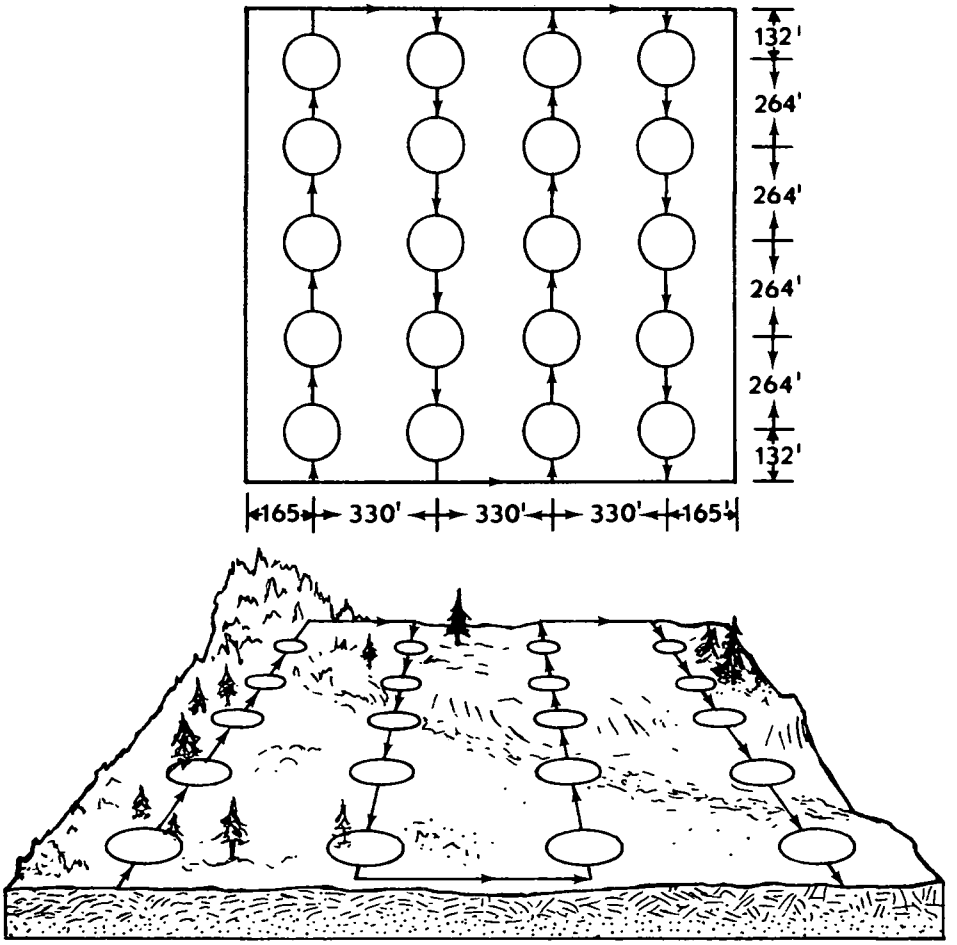

Figure 7. 40-acre area, showing layout of 20 plots (1/5-acre each)

Example:

A cruise of 4 acres has 5 1/5-acre plots.

Plot number	Volume board feet
1	1,327
2	1,729
3	1,625
4	1,276
5	1,536
Total	7,493

$\frac{7493}{5}$ = 1,498.6 average volume per plot.

1,498.6 x 5 = 7,493 average volume per acre

7,493 x 4 = 29,972 estimated board-foot volume for the 4 acres.

Variable-plot sampling

Currently, variable-plot sampling is more frequently used than any other method of timber cruising. It is merely another way of determining which trees to measure. Trees are sighted through a precise ground glass prism which displaces the image of the tree trunk. Figure 8 shows the three ways that trees could appear. For "in" trees, the displaced image overlaps the tree trunk. Tally these "in" trees just as if they had occurred on a fixed-area plot. For "out" trees, the displaced image does not overlap the tree trunk; there is a clear space between the image and the tree trunk. Do not tally "out" trees.

For "borderline" trees, the edge of the displaced image exactly lines up with the edge of the tree trunk. Tally "borderline" trees as a ½ tree rather than as 1 tree—that is, a plot having 8 "in" trees and 1 "borderline" tree would be tallied as 8½ trees.

Each prism is calibrated and assigned a number called the basal area factor (BAF). The most commonly used basal area factors are 20, 30, and 40. The larger the trees and the more dense the stand, the larger the BAF used. Thus, the correct BAF is based on a combination of tree size and the number of trees present. It is recommended that you use a BAF that gives an average tree count of four to eight trees per plot, which usually results in a BAF of 20 to 40.

Table 13. Sample plot dimensions for a zero slope or horizontal distance

Plot size	Circular (radius), feet	Square (side), feet
1	117.8	208.8
½	83.3	147.6
¼	58.9	104.4
1/5	52.7	93.3
1.10	37.2	66.0
1.250	7.45	13.2
1.1000	3.72	6.6

Determine volume per acre by the following steps:

1. Calculate basal area per acre (BA/a). BA/a equals the total number of "in" trees tallied divided by the number of sample plots, times the BAF.
2. Calculate the average volume-basal area ratio (V-BAR). The V-BAR for a tree is that tree's volume divided by its basal area. These tables can be made from any tree volume table. See table 14. Obtain the V-BAR for each tree from the appropriate V-BAR table. Divide the total V-BAR for all trees by the number of trees for the average V-BAR.
3. Calculate the volume per acre by multiplying the BA/a times the average V-BAR.
4. Calculate the total volume for the cruise area by multiplying the volume per acre times the number of acres in the cruise area.

Example:

Suppose 3 sample points were taken on a 4-acre woodlot using a 20 BAF prism. Data collected:

Sample point	Tree no.	Diameter inside bark at 16 feet	Height (no. 16-foot logs)
1	1	12	2
	2	18	4
	3	14	2
	4	16	3
2	1	22	6
	2	18	4
	3	20	6
3	1	16	4
	2	24	7
	3	18	5
	4	14	3
	5	20	6

Step 1—Calculate BA/a

Total number of "in" trees on the 3 sample points is 12. $^{12}/_{3} = 4$, which is the average tree count. BA/a = 4 x 20 (BAF) = 80 square feet per acre

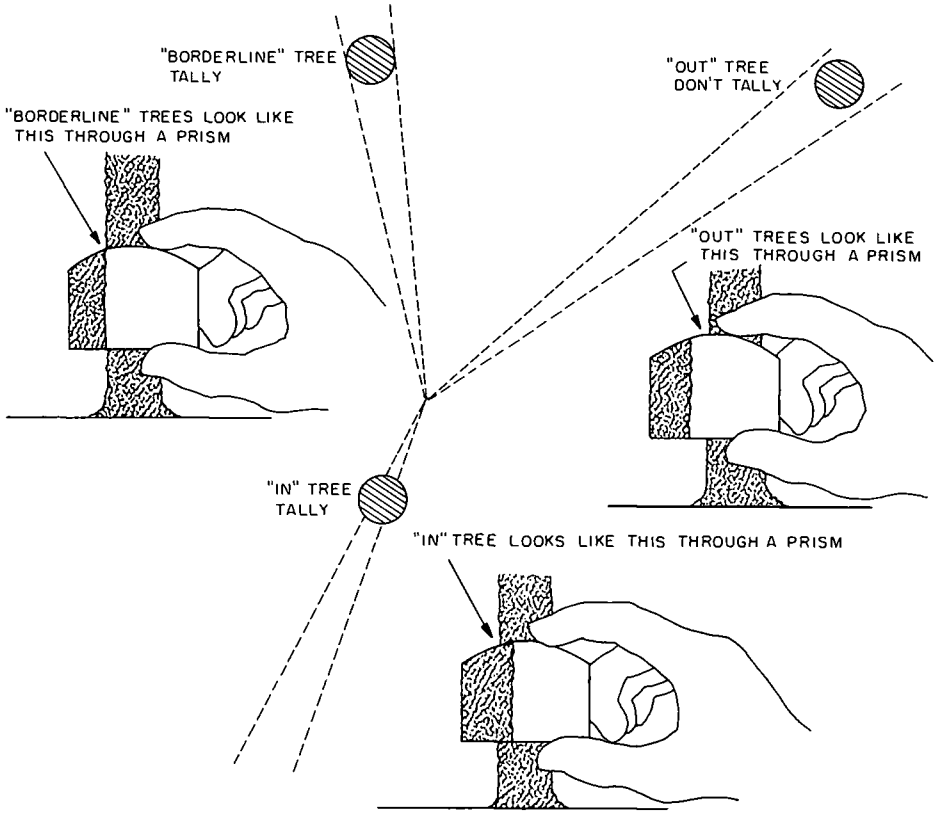

Figure 8. Diagrams of "in," "out," and "borderline" trees as they appear through a wedge prism in variable-plot sampling

Table 14. Volume-basal area ratios for 16-foot logs (volume in Scribner Decimal C per square foot of stem area inside bark at 16 feet)[a]

Inches d.i.b. at 16 feet	Merchantable height in 16-foot logs										
	1	2	3	4	5	6	7	8	9	10	11
10.....	11										
12.....	11	15	23								
14.....	10	14	22	30							
16.....	11	14	21	29	36						
18.....		15	23	30	38	46					
20.....			23	31	38	47	55	63			
22.....				32	40	48	57	65	73		
24.....				32	40	49	57	65	73		
26.....				34	42	51	60	68	77		
28.....				33	41	50	58	66	75		
30.....				34	43	52	60	69	78		
32.....				34	42	51	59	68	76		
34.....				35	44	52	61	70	79	88	
36.....				34	43	51	60	69	77	86	
38.....					43	52	60	69	78	86	
40.....					43	52	61	69	78	87	95
44.....					44	52	61	70	79	87	97
48.....					44	53	62	71	79	88	97
54.....					44	53	62	71	80	89	98
60.....						54	63	72	81	90	99
66.....						54	63	72	81	90	99

[a]Basic volumes derived from Mason, Bruce, and Girard, *Form Class Tables for 16-foot Logs.*

Step 2—Calculate average V-BAR using table 14.

Sample point	Tree number	V-BAR
1	1	15
	2	30
	3	14
	4	21
2	1	48
	2	30
	3	47
3	1	29
	2	57
	3	38
	4	22
	5	47
	Total	398

Average V-BAR = $^{398}/_{12}$ = 33.17

Step 3—Calculate board-foot volume per acre.

Volume per acre = 80 x 33.17 = 2,653.6 Scribner decimal C or 26,536 board feet per acre

Step 4—Calculate total volume.

Total volume = 4 (acres) x 26,536 = 106,144 board feet

When you use form class tables (see page 2), you can observe the trees with the prism at the top of the first 16-foot log, which eliminates the need for estimating form class.

The advantages of variable-plot sampling compared to fixed-plot sampling are:

- No need to determine plot radii.
- Fewer trees to measure.
- You can eliminate form-class determination.

For additional information on variable-plot cruising see *Log Scaling and Timber Cruising* by J. R. Dilworth and *Variable Probability Sampling* by J. R. Dilworth and J. F. Bell (Both available from the OSU Bookstores, Inc., Corvallis, Oregon 97331).

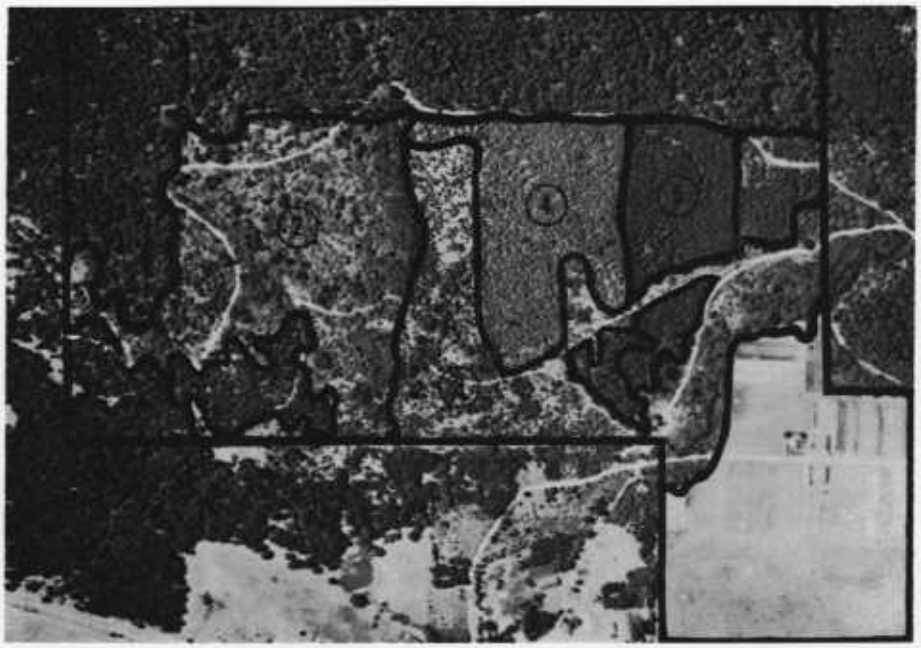

Figure 9. Aerial photo of a farm woodland area. The five numbered areas are identified below as to timber type, approximate age, diameter, and size. Armed with information of this kind and using the plot-cruising method, you can make a reasonable timber estimate. You can obtain photos and other assistance from your county office of the U.S. Department of Agriculture Stabilization and Conservation Service.

Area	Timber type	Age (approx.)	Diameter	Acres
No. 1	Douglas-fir	100	24″ and over	33.2
No. 2	brush, few D.-fir	—	—	22.1
No. 3	Douglas-fir	10 to 28	under 5″	17.5
No. 4	Ponderosa pine	28	5″ to 11″	10.2
No. 5	Douglas-fir	28	5″ to 11″	8.9

Aerial photographs

The small woodland owner may be able to save considerable time and effort by working with aerial photographs.

One source of aerial photographs is the county office of Agricultural Stabilization and Conservation Service. Other sources are the U.S. Forest Service, Bureau of Land Management, and state forestry departments.

Aerial photographs are useful as maps and in locating and identifying the various timber types on an ownership. Figure 9 shows how timber types in a woodland area have been separated by species, size, and approximate age.

Professional assistance

A consulting forester is particularly helpful to a small woodland owner when measuring and selling timber. Consulting foresters furnish their services on a fee basis; these include full tree farm management, appraisal, cruising, marketing, reforestation, surveying, and mapping. Consultants can provide more intensive services than most public foresters. They may also be good contacts for markets and contractors. Lawyers and accountants are particularly helpful for income tax and estate planning questions.

Pacific Northwest *cooperative Extension bulletins are joint publications of the three Pacific Northwest states—Washington, Oregon, and Idaho. Similar crops, climate, and topography create a natural geographic unit that crosses state lines. Since 1949, the PNW program has published over 200 titles. Joint writing, editing, and production has prevented duplication of effort, broadened the availability of faculty specialists, and substantially reduced costs for the participating states.*

This publication *was prepared by John F. Bell, professor of forest management, Oregon State University. It is based on an earlier work by Gary Sanders, Extension forestry specialist, retired. The author acknowledges the assistance of Norman Elwood, Extension forestry management specialist, Oregon State University, and Steve Woodard, Lane County Extension agent.*

Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the Oregon State University Extension Service, Henry A. Wadsworth, director; Washington State University Cooperative Extension, J. O. Young, director; the University of Idaho Cooperative Extension Service, H. R. Guenthner, director; and the U. S. Department of Agriculture cooperating.