U.S. Department of Agriculture
Forest Service Research Paper SE- 196

MULTIRESOURCE INVENTORIES--

A Technique for Measuring Volumes in Standing Trees

by

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December 1978

Southeastern Forest Experiment Station
Asheville, North Carolina

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ABSTRACT.–Procedures for measuring standing trees in forest surveys in the Southeast are described. Field tally sheets and data processing equations are provided.

KEYWORDS: Biomass, mensuration, forest survey, volume tables.

Mensurationists have long recognized the advantage in taking upper-stem measurements of sample trees when determining volumes or preparing volume tables. Until the 1960's, the only practical ways of obtaining upper-stem dimensions were ocular estimation, climbing, or felling of trees, but that problem was solved by the development of several satisfactory dendrometers. Despite these advances and the obvious advantages of taking precise measurements in standing trees, most volume tables are still produced by less efficient methods.

One reason may be that although dendrometers and their use have been fully described, an entire measurement and recording system has not. This Paper describes the system used in forest surveys at the Southeastern Forest Experiment Station to measure standing sample trees for preparation of volume-prediction equations. This system has been refined over the past 14 years, and it should be applicable to many situations. The techniques and procedures described are not the only way to do the job, but their value has been demonstrated over a long period.

In the past 15 years many articles have been published on the different types of dendrometers available for measuring upper-stem diameters (Wheeler 1962; Grosenbaugh 1963; and McClure 1969). The reliability of these instruments has been tested in a host of studies (Nevers and Barrett 1966; Arvanitis 1968; Robbins and Young 1968; Cost 1971; and Bell and Groman 1971), but none of these studies dealt with the mensurational problems associated with measuring standing trees.

In this Paper, I (1) review mensurational problems encountered in measuring standing trees, (2) fully describe the mensurational procedures we use in the Southeast, and (3) provide the data processing equations we use to compute a variety of tree characteristics.

BACKGROUND

In 1963, midway through the third Forest Survey of North Carolina, the Forest Survey Handbook was substantially revised, and merchantability standards were changed. Cubic-foot volumes of wood in the new standards were computed to a 4.0-inch diameter outside bark rather than inside bark. For sawtimber trees, the new standards called for the board-foot volume from a 1-foot stump to a minimum top of 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods. The previous standards for sawtimber had specified minimum top diameters which varied with d.b.h. To accommodate these changes, new prediction equations had to be developed from new tree-volume data.

We studied the merits of both a standing- and felled-tree sample and decided that standing-tree samples were best for most purposes. One advantage is that sample trees are not destroyed. Repeated measurements of them through time permit close estimation of growth. Another big advantage is lower cost per tree, which permits us to sample heavily in each size class with the monies available.

In 1963 we incorporated a standing-tree volume sample into the survey. Species, d.b.h. classes, and tree quality variation were well represented. The measurement procedure was designed to identify all tree components except minor limbs and tops of merchantable limbs.

To measure current utilization practices, internal cull, and upper-stem bark thickness, we have continued to measure some felled trees. Since measurements on felled trees are recorded in the same manner as those on standing trees, the data can be pooled to supplement the standing sample.

Currently, our measurements of standing trees include all branch material in the crown of all trees. Therefore, for the first time, we can determine total-tree volume. The procedures described here are quite flexible and can be applied to any species across a wide geographic range.

PURPOSE

Our standing-tree volume samples are required for several reasons. First, they provide information necessary to develop accurate volume-prediction equations by species. Second, they are used to develop length equations by species. These equations are required to predict average bole length, average saw-log length, or average total height. Third, they provide information to estimate board-foot volume by log grade and to separate cubic volume by material classes. Finally, the measured double bark thickness is used to develop equations for predicting average bark thickness at d.b.h. In the Southeast, the standing-tree volume samples are collected on a proportionate basis, so many of the derived rates, ratios, and factors collected can be extrapolated to the entire sample of permanent plots.

EQUIPMENT

In measuring upper-stem diameters, upper-stem length, and bark thickness, we use three specialized pieces of equipment:

1. *Optical dendrometer.*—All upper-stem diameters from 3 to 16 inches are measured with a 16-inch model mirror caliper. Diameters over 16 inches are measured using a special prism-series attachment. The use of the mirror caliper is described by McClure (1969).
2. *Sectional aluminum pole.*—Each section is 5 feet long and there are 24 sections in a complete set. Thus, it is possible to accurately measure heights up to 120 feet. Construction and use of these poles are described by McClure (1968).
3. *Swedish bark gage.*—Double bark thickness of each tree 3.0 inches d.b.h. or larger is measured with a bark gage. Bark measurements are used to develop regression equations, which in turn are used to convert d.o.b. measurements to d.i.b. estimates.

The measurer also needs to carry a diameter tape to measure the diameter at the 1-foot stump and d.b.h., and an increment borer and hatchet for determining the presence of cull.

GENERAL OBSERVATIONS

After the sample tree has been identified, the marked pole is extended up through the tree crown until it protrudes slightly out the top. Prior to mentally dividing the tree into sections, the following observations should be made.

1. Identify the main stem.
2. Identify the forks.
3. Separate the major limbs and minor limbs.
4. Reconstruct missing material which has broken off.
5. Assign tentative log positions throughout the tree. Look for grade differences, jump sections, and obvious bucking points.
6. Check the tree for signs of internal rot. Rot in the lower portion can often be detected by sounding the tree with a hatchet. Internal defect in the upper portion is classified ocularly, based on surface indicators such as holes, branch stubs, bulges, and conks.
7. Finally, select the plane of the tree that faces the plot center. Repeating this procedure on each sample tree eliminates any bias that might be introduced by elliptical tree cross sections.

RECORDING TREE MEASUREMENTS

Our tally sheet (fig. 1) is designed to facilitate field entries as well as editing, punching, and processing of the data. A separate tally sheet is prepared for each tree 1.0 inch d.b.h. or larger. Our standard code for each entry on the tally sheet is described below. Other codes would probably be needed for other applications. Whatever the application, each item on the tally sheet must be precisely defined to assure standardized entries.

FORM SE-1, JANUARY 1976 — FOREST INVENTORY TREE RECORD — CREW:__________ DATE:__________

LOCATION				TREE				TREE QUALITY					SITE			BARK	SIZE		TREE CLASSIFICATION								
STATE	UNIT	COUNTY	LOCATION	POINT NO.	TREE NO.	SPECIES	D.B.H.	LOG GRADE	CROWN RATIO	CROWN CLASS	DAMAGE	TREE CLASS	SITE CLASS	TREE ORIGIN	PHYSIO. CLASS	DOUBLE BARK AT D.B.H.	TOTAL AGE	TOTAL HEIGHT	FORKS	LIMBS	PRODUCT	NUMBER OF SECTIONS	IDENT. 8OR9	SURVEY CYCLE	OPTION 1	OPTION 2	OPTION 3
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
XX	X	XX	XXX	X	XX	XXX	XXX	X	X	X	XX	X	X	X	XX	XXX	XXX	XXX	X	XX	XX	XX	X	X	XX	XX	XX

TREE SECTIONS									TREE LOGS OR BOLTS												OPTIONAL		
					WORK ZONE	SECTION CULL						UTILIZATION			SWEEP			CROOK					
SECTION NO.	SEC. IDENT.	LOWER D.O.B.	UPPER D.O.B.	SECTION LENGTH	ACC. SEC. LGTHS.	PERCENT CU. FT.	PERCENT BD. FT.	MINOR LIMBS	LOG NUMBER	LOG GRADE	BOLTER LOG	UTILIZ.	PRODUCT	DBLE. BARK TOP OF SECTION	DEPARTURE	LENGTH	D.O.B.	DEPARTURE	LENGTH	D.O.B.	OPTION 1	OPTION 2	OPTION 3
29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
XX	X	XXX	XXX	XXX		XXX	XXX	XX	XX	X	X	X	XX	XXX	XX	XXX	XXX	XX	XX	XXX	XX	XX	XX
01																							
02																							
03																							
04																							
05																							
06																							
07																							
08																							
09																							
10																							
11																							
12																							
13																							
14																							
15																							
16																							
17																							
18																							
19																							
20																							

Figure 1.—Coding sheet Form SE-1.

State (Item 1).—A 2-digit code to identify the State.

Unit (Item 2).—A 1-digit code to identify the survey unit, which for us is the primary subdivision of the State. Management units might be listed in smaller operations.

County (Item 3).—A 2-digit code to identify the county within the State. In smaller applications, a stand number might be entered.

Location (Item 4).—A 3-digit code beginning with 001 in each county to identify separate series of sample location numbers within each county.

Point number (Item 5).—Since a 10-point cluster is the standard plot design used in our forest surveys, one digit is used to identify the point number within the sample location.

Tree number (Item 6).—A 2-digit code beginning with 01 for each point, to identify individual trees on a point.

Species (Item 7).—A 3-digit code to identify the species of the tree being measured. (Species codes are listed in fig. 2.)

D.B.H. (Item 8).—Three digits to identify the diameter to the nearest one-tenth inch of the tree at breast height (4½ feet above the ground). If an irregularity such as a bump or swell occurs at breast height, the diameter is measured immediately above irregularity at the point where the stem is normal. Swell-butted trees such as cypress or tupelo are measured at a point 1.5 feet above the end of the pronounced swell or bottleneck if the bottleneck is more than 3 feet high. A tree that forks below breast height is considered as two trees, and diameter is measured at a point 3½ feet above the point where the two piths intersect. When the stem forks immediately above breast height, diameter is measured below the swell at the point where the stem is normal.

Log grade (Item 9).—A 1-digit code to identify the grade of the first saw log in each sawtimber-size tree. (Grade rules are shown in fig. 2.)

Crown ratio (Item 10).—A 1-digit item that reflects the proportion of total-tree height that supports green, live foliage that contributes to the tree's growth.

Crown class (Item 11).—A 1-digit code to identify the position of the crown in the stand.

Damage (Item 12).—A 2-digit code to identify the presence of any damage or pathogen activity in the tree.

Tree class (Item 13).—A 1-digit code to identify the suitability of trees. The common tree class terms are growing stock or rough and rotten.

Site class (Item 14).—A 1-digit code that denotes the tree-growing potential for the site on which the dendrometered tree subsists.

Tree origin (Item 15).—A 1-digit code to identify if the tree has been planted or established by natural process.

Physiographic class (Item 16).—A 2-digit code to identify the physiographic condition of the area on which the tree subsists. The factors considered include topography, aspect, soil moisture, and drainage.

Double bark at d.b.h. (Item 17).—Double bark thickness at breast height. One bark thickness is taken on the side facing plot center and the other on the opposite side of the tree. The two measurements are added together and recorded to the nearest 0.01 inch. All trees 1.0 inch d.b.h. or larger are measured for double bark. A Swedish bark gage is used to measure bark on all trees 3.0 inches and larger. For trees less than 3.0 inches, a small notch is made and the bark is measured with a finely graduated scale.

Total age (Item 18).—Age of tree being dendrometered.

Total height (Item 19).—Total length (to the nearest foot) from ground level to the tip of the main stem, measured along the main stem.

Forks (Item 20).—A 1-digit code to identify the number of forks that intersect with the main stem between breast height and the 4.0-inch outside diameter (o.b.).

Limbs (Item 21).—Sum of diameters (to the nearest inch) of severe limbs on the main stem and on all forks between breast height and 4.0 inches (o.b.). This value is intended to account for the siphoning effect from merchantable bole volume. If total above-ground tree volume is the objective, the lengths and diameters of all limbs take precedence over this item.

Three guidelines for the identification of a severe limb are:

1. For hardwood species a severe limb's diameter will normally be greater than one-tenth the diameter of the stem on which it occurs.
2. A limb is considered severe if stem diameter decreases markedly immediately above the limb.
3. A severe reduction in stem diameter that requires two dendrometer readings close to each other is normally the result of a severe limb or fork intercept.

Product (Item 22).—A 2-digit code for use in felled-tree utilization studies.

Number of sections (Item 23).—A 2-digit code to identify the number of sections recorded for the entire tree. Leave this space blank until the entire tree has been measured.

Ident. 8 or 9 (Item 24).—A 1-digit code to indicate the method of measurement.

Survey cycle (Item 25).—A 1-digit code to identify the survey cycle (first, second, third, etc.) in which the tree was measured.

Options 1, 2 & 3 (Items 26-28).—Three undefined 2-digit codes for optional items.

Section number (Item 29).—A 2-digit code that is prerecorded on the tally sheet. No sections can be omitted which would cause a break in sequence. This sequence is used as a control feature in editing, computing, and accounting.

CODE	COMMON NAME
	YELLOW PINES
131	Loblolly pine
121	Longleaf pine
126	Pitch pine
128	Pond pine
107	Sand pine
110	Shortleaf pine
111	Slash pine
115	Spruce pine
123	Table-Mt. pine
132	Virginia pine
	OTHER SOFTWOODS
043	Atlantic white-cedar
221	Baldcypress
010	Fir
260	Hemlock
241	Northern white-cedar
222	Pondcypress
060	Redcedar
090	Spruce
129	White pine
	SOFT HARDWOODS
950	Basswood
762	Black cherry
694	Blackgum (lowland)
693	Blackgum (upland)
313	Boxelder
330	Buckeye
601	Butternut
740	Cottonwood
651	Cucumbertree
970	Elm
460	Hackberry
555	Loblolly-bay
652	Magnolia
316	Red maple
580	Silverbell (in mts.)
317	Silver maple
653	Sweetbay
611	Sweetgum
731	Sycamore
691	Water tupelo
920	Willow
621	Yellow-poplar
	HARD HARDWOODS
540	Ash
531	Beech
370	Birch (except yellow)
901	Black locust
837	Black oak
602	Black walnut
823	Bur oak
813	Cherrybark oak
832	Chestnut oak
826	Chinkapin oak
491	Dogwood
311	Florida maple
400	Hickory
591	Holly
552	Honeylocust
820	Laurel oak
838	Live oak
680	Mulberry
822	Overcup oak
521	Persimmon (forest grown)
830	Pin oak
835	Post oak
833	Northern red oak
806	Scarlet oak
817	Shingle oak
834	Shumard oak
812	Southern red oak
318	Sugar maple
825	Swamp chestnut oak
804	Swamp white oak
827	Water oak
802	White oak
831	Willow oak
371	Yellow birch
	MISCELLANEOUS
816	Bear oak
824	Blackjack oak
807	Bluejack oak
841	Dwarf live oak
840	Dwarf post oak
819	Turkey oak
899	Other scrub oaks
341	Ailanthus
548	American mt. ash
391	Blue beech
451	Catalpa
310	Chalk maple
421	Chestnut
661	Chinaberry
660	Domestic fruit (apple, etc.)
760	Fire cherry
701	Eastern hophornbeam
319	Mountain maple
692	Ogeechee gum
641	Osage-orange
521	Persimmon (field grown)
722	Planertree (water elm)
721	Redbay
471	Redbud
712	Royal paulownia
931	Sassafras
352	Serviceberry
581	Silverbell (except mts.)
711	Sourwood
315	Striped maple
999	Other miscellaneous trees

PHYSIOGRAPHIC CLASS

11	High mountain tops and slopes
12	Sand dunes and sand ridges
13	Low mountain tops and dry slopes
14	Sand hills
15	Mountain foothills
10	Other xeric
21	Flatwoods and dry pocosins
22	Rolling uplands
23	Bluffs
24	Mountain saddles and moist slopes
25	Natural stream levees
26	Valley bottoms
27	Mountain coves
28	Narrow stream margins
29	Broad stream margins
20	Other mesic
31	Deep swamps
32	Cypress strands
33	Small drains
34	Cypress ponds
35	Willow heads and strands
36	Bays and wet pocosins
37	Marl flats and forest prairies
30	Other hydric

SECTION IDENT.

0	Stump section
1	Saw log section, main stem
2	Upper stem section, main stem
3	Top section, main stem
4	Saw log section, fork
5	Upper stem section fork
6	Top section, fork
7	Major limb
8	Top section, major limb
9	Minor limb

CROWN CLASS

1	Open grown
2	Dominant
3	Codominant
4	Intermediate
5	Overtopped

CROWN RATIO
(percent of live crown)

1	0-9
2	10-19
3	20-29
4	30-39
5	40-49
6	50-59
7	60-69
8	70-79
9	80-89
0	90-99

DAMAGE CODES

00	No damage
10	Insects
20	Other disease
21	Fusiform rust
22	Annosus root rot
23	Littleleaf disease
24	Blister rust
25	Hardwood cankers
26	Branch stubs (5% cull)
27	Top breakage (5% cull)
28	Other basal defects (5% cull)
30	Fire
40	Animal
50	Weather
60	Suppression and stagnation
80	Logging and related
84	Turpentining
90	Form (damaging)
	Saplings only
91	Form (culling)
92	Off site (damaging)
93	Off site (culling)

TREE CLASS

1	Desirable tree
2	Acceptable tree
3	Rough tree
4	Rotten tree

TREE ORIGIN

0	Natural
1	Planted

SITE CLASS
POTENTIAL YIELD, MEAN ANNUAL INCREMENT

1	More than 165 cubic feet per acre
2	120 to 165 cubic feet per acre
3	85 to 120 cubic feet per acre
4	50 to 85 cubic feet per acre
5	Less than 50 cubic feet per acre

Continued

Figure 2.—Coding summary for Form SE-1.

LOG GRADES FOR HARDWOOD FACTORY LUMBER LOGS (Third-best face in butt log)

Log length	Scaling diameter of log																																		
	8	9	10		11		12			13			14			15			16			18			20			22			24			26+	
	Log grade																																		
	3	3	2	3	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
8-ft. logs																																				
Clear cuttings:																																				
Min. length	2	2	—	2	—	2	Only ash, basswood	3	2	—	3	2	—	3	2	—	3	2	—	3	2	—	3	2	—	3	2	—	3	2	—	3	2	—	3	2
Max. number	4	4	—	4	—	4		2	4	—	2	4	—	2	4	—	2	4	—	2	4	—	2	4	—	2	4	—	2	4	—	2	4	—	2	4
Min. total length	4	4	—	4	—	4		6	4	—	5	4	—	5	4	—	5	4	—	5	4	—	5	4	—	5	4	—	5	4	—	5	4	—	5	4
Max. sweep, inches	2	2	—	2	—	3		3	3	—	3	3	—	3	3	—	4	4	—	4	4	—	4	4	—	5	5	—	5	5	—	6	6	—	1/4D	1/4D
Max. crook, inches	3	3	—	3	—	4		4	4	—	4	4	—	5	5	—	5	5	—	5	5	—	6	6	—	7	7	—	7	7	—	8	8	—	1/3D	1/3D
Max. total cull, bd.-ft.	8	11	—	14	—	18		22	22	—	26	26	—	31	31	—	36	36	—	42	42	—	54	54	—	68	68	—	84	84	—	101	101	—	50%	50%
10-ft. logs																																				
Clear cuttings:																																				
Min. length	2	2	8	2	3	2	8	3	2	8	3	2	8	3	2	8	3	2	8	3	2	8	3	2	8	3	2	8	3	2	8	3	2	8	3	2
Max. number	5	5	1	5	2	5	1	2	5	1	2	5	1	2	5	1	2	5	1	2	5	1	2	5	1	2	5	1	2	5	1	2	5	1	2	5
Min. total length	5	5	8	5	7	5	8	7	5	8	7	5	8	7	5	8	7	5	8	7	5	8	7	5	8	7	5	8	7	5	8	7	5	8	7	5
Max. sweep, inches	2	3	3	3	3	3	2	4	4	2	4	4	2	4	4	2	5	5	3	5	5	3	6	6	3	6	6	4	7	7	4	7	7	1/6D	.3D	1/3D
Max. crook, inches	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	7	7	7	7	7	7	8	8	8	1/3D	1/3D	1/3D
Max. total cull, bd.-ft.	11	14	18	18	23	23	23	28	28	27	34	34	32	40	40	37	46	46	43	54	54	56	69	69	70	87	87	86	107	107	103	128	128	40%	50%	50%
12-ft. logs																																				
Clear cuttings:							Ash																													
Min. length	2	2	10	2	3	2	10	3	2	10	3	2	10	3	2	10	3	2	5	3	2	5	3	2	3	3	2	3	3	2	3	3	2	3	3	2
Max. number	6	6	1	6	2	6	1	3	6	1	3	6	1	3	6	1	3	6	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6	2	3	6
Min. total length	6	6	10	6	8	6	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6	10	8	6
Max. sweep, inches	3	3	4	4	4	4	3	4	4	3	5	5	4	5	5	4	6	6	4	6	6	4	7	7	4	7	7	5	8	8	5	9	9	.2D	.4D	.4D
Max. crook, inches	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	7	7	7	7	7	7	8	8	8	1/3D	1/3D	1/3D
Max. total cull, bd.-ft.	13	18	23	23	28	28	28	34	34	33	41	41	39	49	49	46	57	57	52	65	65	68	84	84	85	106	106	104	129	129	124	155	155	40%	50%	50%
14-ft. logs																																				
Clear cuttings:							Ash																													
Min. length	2	2	7	2	3	2	7	3	2	7	3	2	7	3	2	7	3	2	5	3	2	5	3	2	3	3	2	3	3	2	3	3	2	3	3	2
Max. number	7	7	2	7	2	7	2	3	7	2	3	7	2	3	7	2	3	7	2	3	7	2	3	7	2	3	7	2	3	7	2	3	7	2	3	7
Min. total length	7	7	12	7	9	7	12	9	7	12	9	7	12	9	7	12	9	7	12	9	7	12	9	7	12	9	7	12	9	7	12	9	7	12	9	7
Max. sweep, inches	3	4	4	4	5	5	4	5	5	4	6	6	4	6	6	4	6	7	4	7	7	4	7	8	5	8	9	5	8	10	5	9	10	.2D	.4D	.4D
Max. crook, inches	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	7	7	7	7	7	7	8	8	8	1/3D	1/3D	1/3D
Max. total cull, bd.-ft.	16	21	27	27	34	34	33	41	41	40	49	49	47	58	58	54	67	67	62	78	78	80	100	100	100	125	125	122	153	153	147	184	184	40%	50%	50%

(continued).

Figure 2.—Coding summary for Form SE-1 (continued).

LOG GRADES FOR HARDWOOD FACTORY LUMBER LOGS (*Third-best face in butt log*) (*continued*)

Log length	*Scaling diamter of log* 8	9	10		11		12			13			14			15			16			18			20			22			24			26+		
Log grade	3	3	2	3	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
16-ft. logs																																				
Clear cuttings:							Ash																													
Min. length	2	2	7	2	3	2	7	3	2	7	3	2	7	3	2	7	3	2	5	3	2	5	3	2	3	3	2	3	3	2	3	3	2	3	3	2
Max. number	8	8	2	8	2	8	2	3	8	2	3	8	2	3	8	2	3	8	2	3	8	2	3	8	2	3	8	2	3	8	2	3	8	2	3	8
Min. total length	8	8	13	8	11	8	13	11	8	13	11	8	13	11	8	13	11	8	13	11	8	13	11	8	13	11	8	13	11	8	13	11	8	13	11	8
Max. sweep, inches	4	4	5	5	5	5	4	6	6	4	6	6	4	6	7	4	6	7	4	7	8	5	7	9	5	8	10	5	9	11	6	9	12	.2D	.4D	.5D
Max. crook, inches	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	7	7	7	7	7	7	8	8	8	1/3D	1/3D	1/3D
Max. total cull, bd.-ft.	19	25	32	32	40	40	39	48	48	46	57	57	54	68	68	63	78	78	72	90	90	93	116	116	116	145	145	142	177	177	170	212	212	40%	50%	50%
18-ft. logs							Ash																													
Clear cuttings:																																				
Min. length	2	2	7	2	3	2	7	3	2	7	3	2	7	3	2	7	3	2	5	3	2	5	3	2	3	3	2	3	3	2	3	3	2	3	3	2
Max. number	9	9	2	9	2	9	2	3	9	2	3	9	2	3	9	2	3	9	2	3	9	2	3	9	2	3	9	2	3	9	2	3	9	2	3	9
Min. total length	9	9	15	9	12	9	15	12	9	15	12	9	15	12	9	15	12	9	15	12	9	15	12	9	15	12	9	15	12	9	15	12	9	15	12	9
Max. sweep, inches	4	5	5	6	6	6	4	6	7	4	6	7	4	6	8	4	7	8	5	7	9	5	8	10	5	8	11	6	9	12	6	9	13	.2D	.4D	.6D
Max. crook, inches	3	3	3	3	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	7	7	7	7	7	7	8	8	8	1/3D	1/3D	1/3D
Max. total cull, bd. ft.	22	30	37	37	47	47	44	55	55	54	67	67	62	77	77	72	90	90	82	102	102	106	132	132	132	165	165	162	202	202	194	242	242	40%	50%	50%

SOUTHERN PINE GRADES

For softwoods, always grade the bottom 16-foot log, or the first merchantable log 12 feet or longer in the tree.

Face = 1/4 the circumference of the log.

Clear Face = Free of knots measuring more than 1/2 inch in diameter, overgrown knots of any size, holes more than 1/4 inch in diameter. The faces may be rotated if necessary to obtain the maximum number of clear ones.

Overgrown Knot = A knot overgrown and buried beneath the log surface, but indicated by a surface bump or disturbance of bark pattern.

Tentative Grades

Grade 1.—Logs with 3 or 4 clear faces.
Grade 2.—Logs with 1 or 2 clear faces.
Grade 3.—Logs with no clear faces.

Degrade for Sweep or Heart Rot

a. Degrade any tentative 1 or 2 log one grade if sweep amounts to 3 or more inches and equals or exceeds one-third (1/3) the diameter inside bark at small end. This is the final grade if there is no evidence of heart rot.

b. Degrade any tentative 1 or 2 log one grade if conk, massed hyphae, or other evidence of advanced heart rot is found anywhere in it.

HARDWOOD TIE AND TIMBER GRADE
(Examine entire log)

Scaling diameter.—8-inch minimum
Log length.—8-foot minimum
Knots or limbs:
Single knot or limb does not exceed 1/3 stem diameter at point of occurrence.
Grouped knots or limbs.—Sum of diameters in any 6-inch stem section does not exceed 1/3 stem diameter at point of occurrence.

Maximum sweep allowed (inches departure)

Log length	Maximum sweep by log scaling diam. 8	10	12	14	16	18	20	22	24	26+
8	2	2	3	3	4	4	5	5	6	1/4D
10	2	3	4	4	5	6	6	7	7	1/3D
12	3	4	4	5	6	7	7	8	9	.4D
14	3	4	5	6	7	8	9	10	10	.4D
16	4	5	6	7	8	9	10	11	12	.5D
18	4	6	7	8	9	10	11	12	13	.6D

Maximum crook allowed.—Departure in inches not to exceed 1/3 diameter of log segment at point of occurrence.
Internal rot.—None allowed.
Total cull.—Not over 50% of gross board-foot volume.

Figure 2.—Coding summary for Form SE-1 (*continued*).

Section identification (Item 30).—A 1-digit code to identify the type of material represented by the section's measurements. Ten identity codes represent the portions of the entire tree from ground to the tip (fig 3):

Main stem codes

Code 0 – Stump material.

Code 1 – Softwood material 7.0+ inches or hardwood material 9.0+ inches.

Code 2 – Softwood material 7.0 inches to 4.0 inches, or hardwood material 9.0 inches to 4.0 inches.

Code 3 – Softwood or hardwood material 4.0 inches to 0.0 inch.

Fork codes

Code 4 – Softwood material 7.0+ inches or hardwood material 9.0+ inches.

Code 5 – Softwood material 7.0 inches to 4.0 inches, or hardwood material 9.0 to 4.0 inches.

Code 6 – Softwood or hardwood material 4.0 inches to 0.0 inch.

Major limb codes

Code 7 – Softwood or hardwood material 4.0 inches or larger at the limb base and 4.0 inches at the small end.

Code 8 – Softwood or hardwood material 4.0 inches to 0.0 inch.

Minor limb code

Code 9 – Softwood or hardwood limb 0.5 inch to 4.0 inches at the limb base, that occurs on the main stem, forks, and major limbs, to the tip.

The separation of limbs and forks in some hardwood species is sometimes difficult. The general rules for making this separation are:

1. The diameter of a limb is normally less than half the diameter of the main stem, at the point of branching.
2. A limb will usually occur at an angle of from 45° to 90° in relation to the main stem.
3. Limbs often occur in multiples at the point of branching. Forks generally result in two stems.
4. The first major branching from the main stem is usually a fork. Subsequent branching further up the stem will tend to be limbs.
5. A limb will not ordinarily have the potential of containing a merchantable saw log.

Lower diameter outside bark (Item 31).—The lower diameter of each section measured in the tree. Measurement of tree diameters starts at the ground. The stump section (No. 01) will have a groundline and upper d.o.b. greater than the tree's d.b.h. The lower d.o.b. for sections 02, 03, etc., will be equal to or less than the upper d.o.b. of the previous section unless a new fork or limb is started. All lower d.o.b. measurements must be equal to or greater than the upper d.o.b. of the same section.

No d.o.b. measurements are taken at points of abnormal swell or within limb or fork swells. When a measurement point occurs within one of these areas, the section length is carried to the pith intercept, the upper-section lower d.o.b. is taken above the swell, and the lower-section upper d.o.b. is taken below the swell. This procedure excludes the swell material, yet accounts for the reduction in stem diameter at this point.

Stem distortion due to bark irregularities must be considered. Comparing mechanical caliper and optical caliper readings provides a basis for adjusting dendrometer readings downward. Each tree should be measured from point center or opposite point center to prevent accumulated bias from tree ellipiticalness.

The lower d.o.b. of sections identified as tops (codes 3, 6, or 8) should not be larger than 4.0 inches o.b. For sections identified as minor limbs (code 9), lower d.o.b. can represent (1) the actual d.o.b. of one minor limb, or (2) an average d.o.b. (to the nearest 1-inch class) for several minor limbs in the tree having about the same diameter at the limb base. For example, five minor limbs with diameters of 0.6, 0.9, 1.1, 1.2, and 1.4 would have an average d.o.b. of 1.0 (recorded as 010). No lower d.o.b. should be left blank or recorded as 00.0.

Upper diameter outside bark (Item 32).—A 3-digit item to identify the upper diameter of each section measured in the tree. The general rules covered in lower d.o.b. apply to upper d.o.b. with a few exceptions. The upper d.o.b. of sections identified as saw-log material (code 1 or 4) should not be less than 7.0 inches for softwoods and 9.0 inches for hardwoods. Sections identified as upper-stem material (codes 2, 5, or 7) should not be below 4.0 inches d.o.b.

In normally tapering trees, the upper d.o.b. of the section will be the lower d.o.b. of the next section, as long as forks or limbs are not encountered.

Section length (Item 33).—The length of the section being measured to the nearest 0.1 foot. A marked pole is used to measure section length. Saw-log sections should be 4.0 feet long whenever possible. Upper-stem sections should be 5.0 feet long. Top and limb sections may be any length but should be broken into more sections if severe taper is caused by limbs.

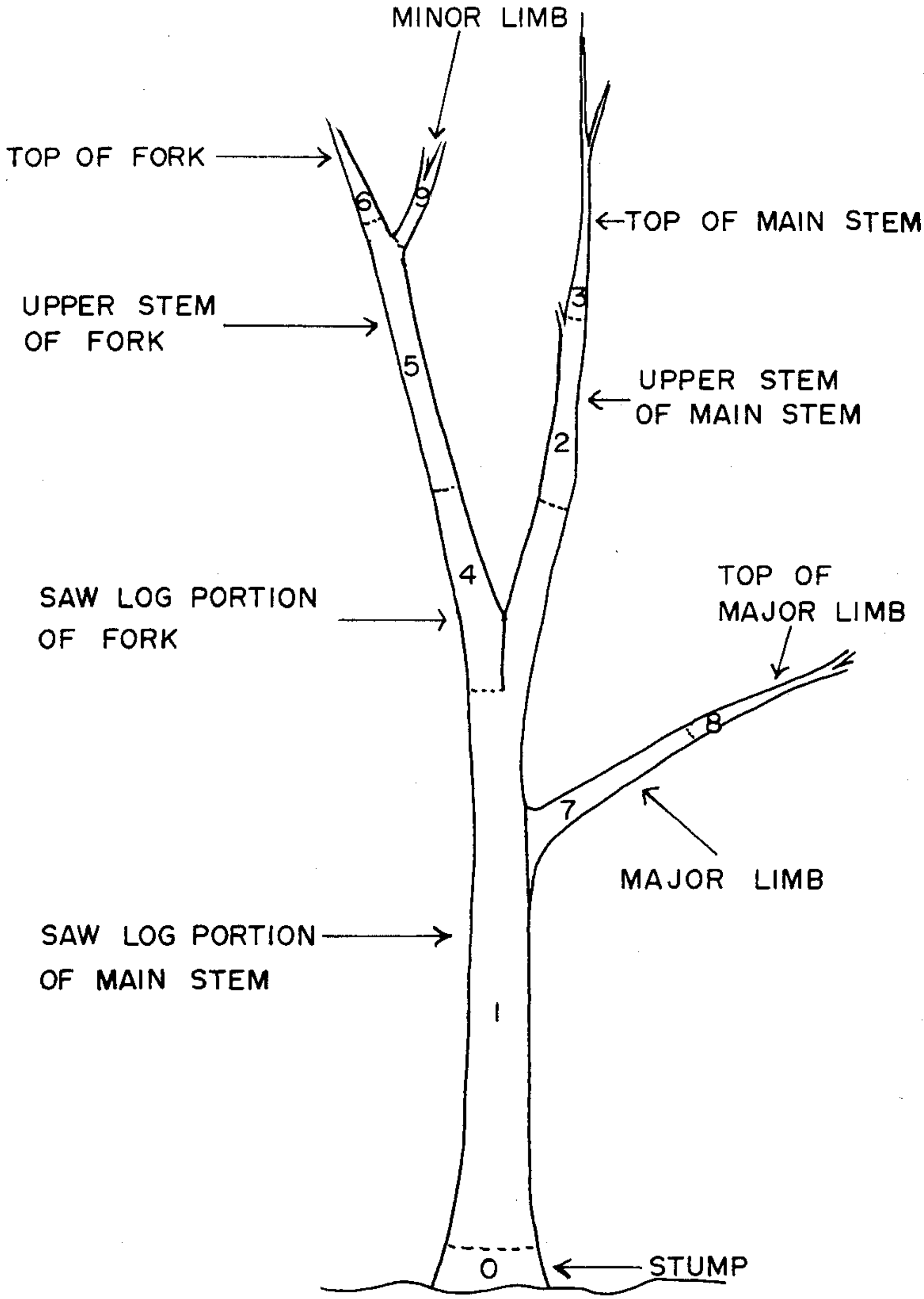

FIG. 3 - SECTION IDENTITY CODES

Figure 3.—Section identity codes.

Accumulated section lengths (Item 34).—A work space for tallyman to accumulate the total length of section codes 0, 1, 2, or 3 for sawtimber-size trees and codes 0, 2, and 3 for trees 4.0 inches d.b.h. to sawtimber-size trees. The accumulated length should agree with the total height recorded in Item 19. This item is only for field use; it is not used in computer processing.

Cubic-foot cull percentage (Item 35).—The percentage of internal cull in each section that results from rot or missing wood. Tree sections that have been turpentined are not considered cubic cull; they can be used for pulpwood, fenceposts, or fuelwood. Sweep, crook, forks, and limbs are not considered cubic-foot cull. In softwoods, no cull volume should be deducted for sound knots.

The presence of cubic cull can be determined in one of two ways, depending on where it occurs in the tree. If cull is suspected in the lower portion of the tree, it can be detected by sounding with a hatchet or by extracting a core with an increment borer. For sections out of reach, one must look for external indicators as a basis for cull determination.

For a rule of thumb, the cubic cull percentage can be computed in the following manner:

$$\text{Cubic cull percentage} = \frac{(\text{diameter of cull portion})^2}{(\text{diameter inside bark})^2}\ (100)$$

Board-foot cull percentage (Item 36).—The percentage of board-foot cull in each saw-log section and bolter-log section resulting from rot, roughness, or other defect. These defects reduce the amount of lumber otherwise recoverable from a log. The kinds of defects considered include butt wounds, forks, large limbs, surface wounds (such as lightning scars), red heart, embedded wire or nails, and broken tops.

Three formulas, as outlined by Grosenbaugh (1952), are well suited for computing board-foot cull percentage for the defects listed. In all three formulas, d is average diameter inside bark at small end of log, and L is length of the section in feet.

1. Board-foot cull percentage when defect affects entire cross section:

$$\left(\frac{\text{Length of defect}}{L}\right)\ (100)$$

2. Board-foot cull percentage when defect is shaped as a wedge:

$$\left(\frac{\text{Length of defect}}{L}\right)\left(\frac{\text{Central angle of defect}}{360^\circ}\right)(100)$$

3. Board-foot cull percentage when the average cross section of interior defect is enclosable in ellipse or circle with major and minor diameter measurable in inches:

$$\left(\frac{(\text{Major})\,(\text{Minor})}{(d-1)^2}\right)\left(\frac{\text{Length of defect}}{L}\right)(100).$$

Minor limbs (Item 37).—A 2-digit code to identify the number of minor limbs in designated size class. Since there is a tendency for limbs to vary in size and length, it is necessary to segregate the limbs into different classes. Two broad classes of minor limbs are recognized:

1. A single limb much larger in diameter or length than other limbs on the tree.
2. Several limbs either in a bunch or scattered throughout the tree, that are about the same diameter and length.

When one minor limb is singled out to be measured, a 01 is recorded. If several limbs are averaged together, the total number of limbs is recorded for the minor limb count.

Log number (Item 38).—A 2-digit code which separates the tree into a series of material classes. Each merchantable log and bolter log within the main stem or forks of a tree is given a unique number. Each section within the log is assigned this number. In addition, each jump section, upper stem, top, stump, or limb section within the tree is assigned a separate log number (fig. 4).

Log grade (Item 39).—A 1-digit item to identify the log grade of each merchantable section in the saw-log portion of the tree. For grading purpose, each merchantable section is assembled into 8- to 16-foot logs. For hardwoods, log sections are visually squared up into four sides or faces. The face with the most defects is disregarded. Grade determination is based upon scaling diameter and number and length of clear sections without defect on the poorest of the three remaining faces. Southern pine grade is based entirely upon the number of clear faces. A face is one-fourth of the circumference in width and extends the full length of the log. All other softwood species are graded by white pine grade rules.

Bolter log (Item 40).—A 1-digit code to identify whether the section meets the requirements for a hardwood bolter log. These requirements are:

1. Length normally 4 to 8 feet and not less than 4 feet.
2. Scaling diameter of at least 7.0 inches o.b.
3. Must meet minimum requirements for a grade 3 Hardwood Factory Lumber

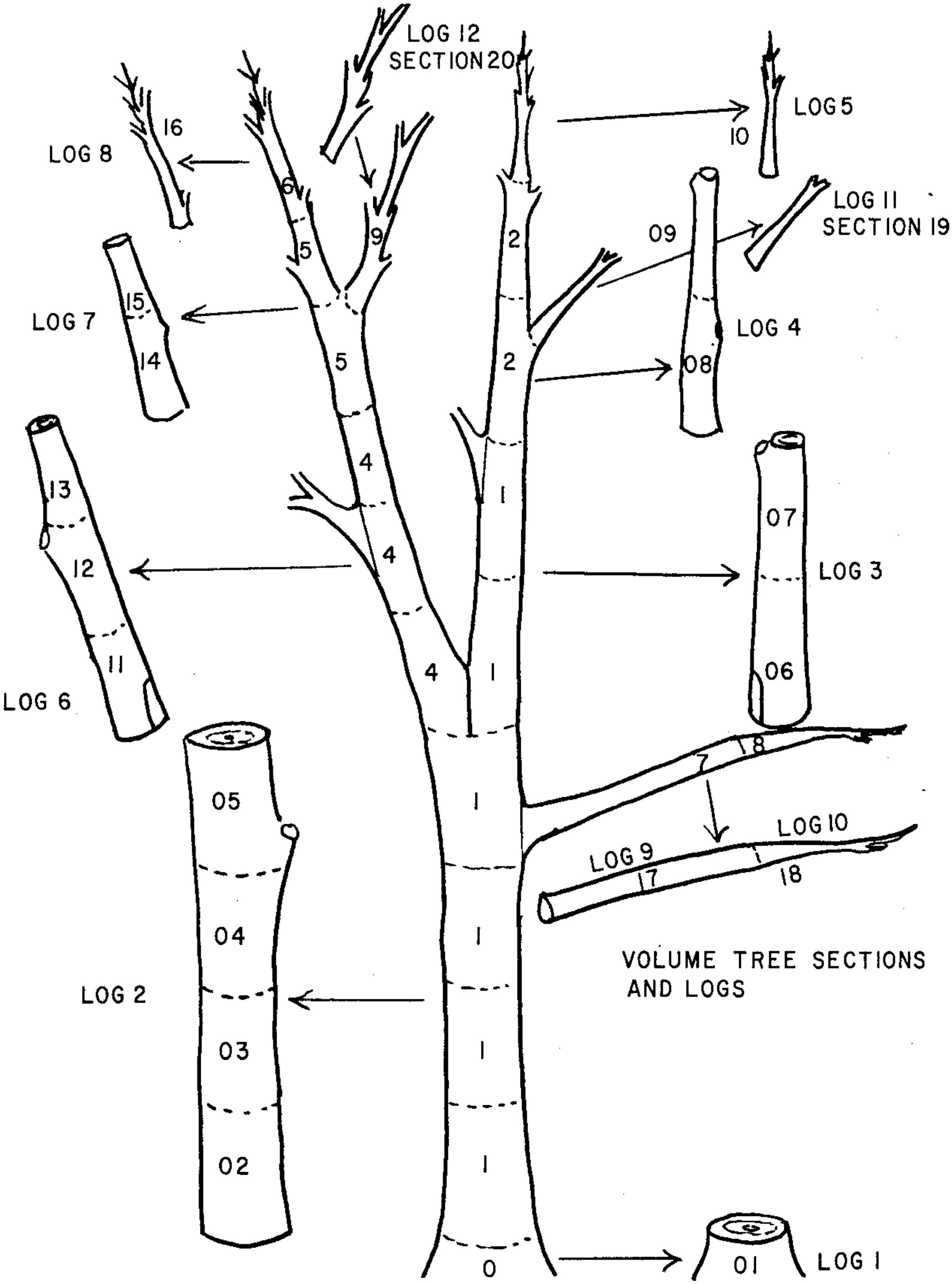

Figure 4.—Volume tree sections and log numbers.

Log (fig. 2). For logs less than 8 feet, the grade specifications are prorated, based on length.

Utilization (Item 41).—A 1-digit code for use in a felled-tree utilization study.

Product (Item 42).—A 1-digit code for use in a felled-tree utilization study.

Double bark thickness, top of section (Item 43).—A 3-digit code for use in a felled-tree utilization study.

Sweep departure (Item 44).—A 2-digit code to quantify sweep in the log. One inch or less of sweep per 8 feet of log is ignored. Sweep departure is recorded when the central axis or the portion with sweep departs more than 1 inch from an imaginary straight line that connects the centers at the ends of the log.

Sweep length (Item 45).—The length of the portion of the log with sweep to the nearest 0.1 foot. Sweep is generally 6 feet or more in length.

Sweep d.o.b. (Item 46).—Scaling diameter of the portion of the log with sweep.

Crook departure (Item 47).—A 2-digit code to identify an abrupt bend deviating from the straight longitudinal axis of the log.

Crook length (Item 48).—The length of the portion of the log with crook to the nearest 0.1 foot. Crooks are generally less than 6 feet in length.

Crook d.o.b. (Item 49).—Scaling diameter of the portion of the log with crook.

Options 1, 2 & 3 (Items 50-52).—Three 2-digit codes for optional items. If other pertinent information is needed by tree section, these items can be activated.

Figure 5 shows a tally sheet that is completed. The lower and upper d.o.b.'s for each tree section are shown in figure 6.

DATA PROCESSING

Conversion of the information collected on standing trees into volume equations requires the assistance of an electronic computer. We transfer all sample-tree data from the field forms to punched cards. These cards are run through a comprehensive editing program which identifies valid codes, omissions, incorrect measurements, and illogical section sequences or relationships between various measurements and classifications. Error listings identify the types of errors. After the initial errors are corrected, a second edit is made to ensure that new errors have not been introduced.

Next, the data are processed with a special volume computer program which computes diameters inside bark, section volumes and losses to sweep or crook, and summaries of volume by material class and quality.

Finally, for each tree, two levels of information are produced and stored on magnetic tape for future retrieval. One tape contains tree sections in full detail, while the other is a special tree summary.

BARK COEFFICIENT

If volume without bark is one of the objectives, all outside diameters must be converted to diameters inside bark (d.i.b.). Bark coefficients used to estimate d.i.b. are derived with computer-generated regression equations which predict double bark thickness as a function of diameter outside bark (d.o.b.) by species. Two bark coefficients result from each equation model:

$$Y_1 = a + b(\text{d.b.h.})$$

$$Y_2 = c + d(\text{d.o.b.})$$

where:

Y_1 = double bark thickness at 4.5 feet above ground (inches)

Y_2 = double bark thickness above 4.5 feet (inches)

a, b, c, d = regression coefficients

d.o.b. = diameter outside bark

d.b.h. = diameter at 4.5 feet

Observed values of Y_2 for computation of the regression equation are obtained from felled trees.

PROGRAMED EQUATIONS

The method for estimating bark thickness at a point depends on the point's height above ground. The steps that are involved are:

1. The measured double bark thickness at breast height is used to adjust the predicted bark thickness based on the ratio difference found at breast height. This difference is expressed as a bark adjustment factor (b.a.f.).
2. For a point 7 feet in height or less, the equation for predicting double bark thickness is:

$$\text{Double bark thickness (inches)} = [a + b(\text{d.o.b.})]\,(\text{b.a.f.})$$

3. For a point above 7 feet but less than 16 feet in height, the two equations are blended:

$$B_1 = \left[\frac{\text{Height above ground} - 7.0}{9.0}\right]\left[c + d\,(\text{d.o.b.})\right]$$

FORM SE-1, JANUARY 1976 — FOREST INVENTORY TREE RECORD — CREW: [illegible] DATE: 11/27/78

LOCATION				TREE				TREE QUALITY					SITE			BARK	SIZE		TREE CLASSIFICATION								
STATE	UNIT	COUNTY	LOCATION	POINT NO.	TREE NO.	SPECIES	D.B.H.	LOG GRADE	CROWN RATIO	CROWN CLASS	DAMAGE	TREE CLASS	SITE CLASS	TREE ORIGIN	PHYSIO. CLASS	DOUBLE BARK AT D.B.H.	TOTAL AGE	TOTAL HEIGHT	FORKS	LIMBS	PRODUCT	NUMBER OF SECTIONS	IDENT. 8 OR 9	SURVEY CYCLE	OPTION 1	OPTION 2	OPTION 3
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
XX	X	XX	XXX	X	XX	XXX	XXX	X	X	X	XX	X	X	X	XX	XXX	XXX	XXX	X	XX	XX	XX	X	X	XX	XX	XX
39	2	03	001	1	01	827	145	3	7	2	00	2	4	0	29	115	—	056	1	18	—	20	1	5	—	—	—

TREE SECTIONS									TREE LOGS OR BOLTS												OPTIONAL		
				WORK ZONE	SECTION CULL							UTILIZATION			SWEEP			CROOK					
SECTION NO.	SEC. IDENT.	LOWER D.O.B.	UPPER D.O.B.	SECTION LENGTH	ACC. SEC. LGTHS.	PERCENT CU. FT.	PERCENT BD. FT.	MINOR LIMBS	LOG NUMBER	LOG GRADE	BOLTER LOG	UTILIZ.	PRODUCT	DBLE. BARK TOP OF SECTION	DEPARTURE	LENGTH	D.O.B.	DEPARTURE	LENGTH	D.O.B.	OPTION 1	OPTION 2	OPTION 3
29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
XX	X	XXX	XXX	XXX		XXX	XXX	XX	XX	X	X	X	XX	XXX	XX	XXX	XXX	XX	XX	XXX	XX	XX	XX
01	0	240	195	010	1	000			01														
02	1	195	140	040	5		000		02	3													
03	1	140	130	040	9				02	3													
04	1	130	128	040	13				02	3													
05	1	128	128	020	15				02	3													
06	1	103	098	040	19				03	3													
07	1	098	092	040	23				03	3													
08	1	092	090	020	25		↓		03	3													
09	2	090	075	050	30				04		1												
10	2	075	060	050	35				05														
11	2	060	040	030	38				05														
12	3	040	000	180	56				06														
13	4	100	096	040			000		07	3													
14	4	096	090	040			↓		07	3													
15	5	090	070	050					08		1												
16	5	070	062	060					09														
17	6	040	000	130					10														
18	7	056	040	130					11														
19	8	040	000	090					12														
20	9	030	000	120		↓		04	13														

Figure 5.—Coding sheet Form SE-1 containing data for sample tree in figure 6.

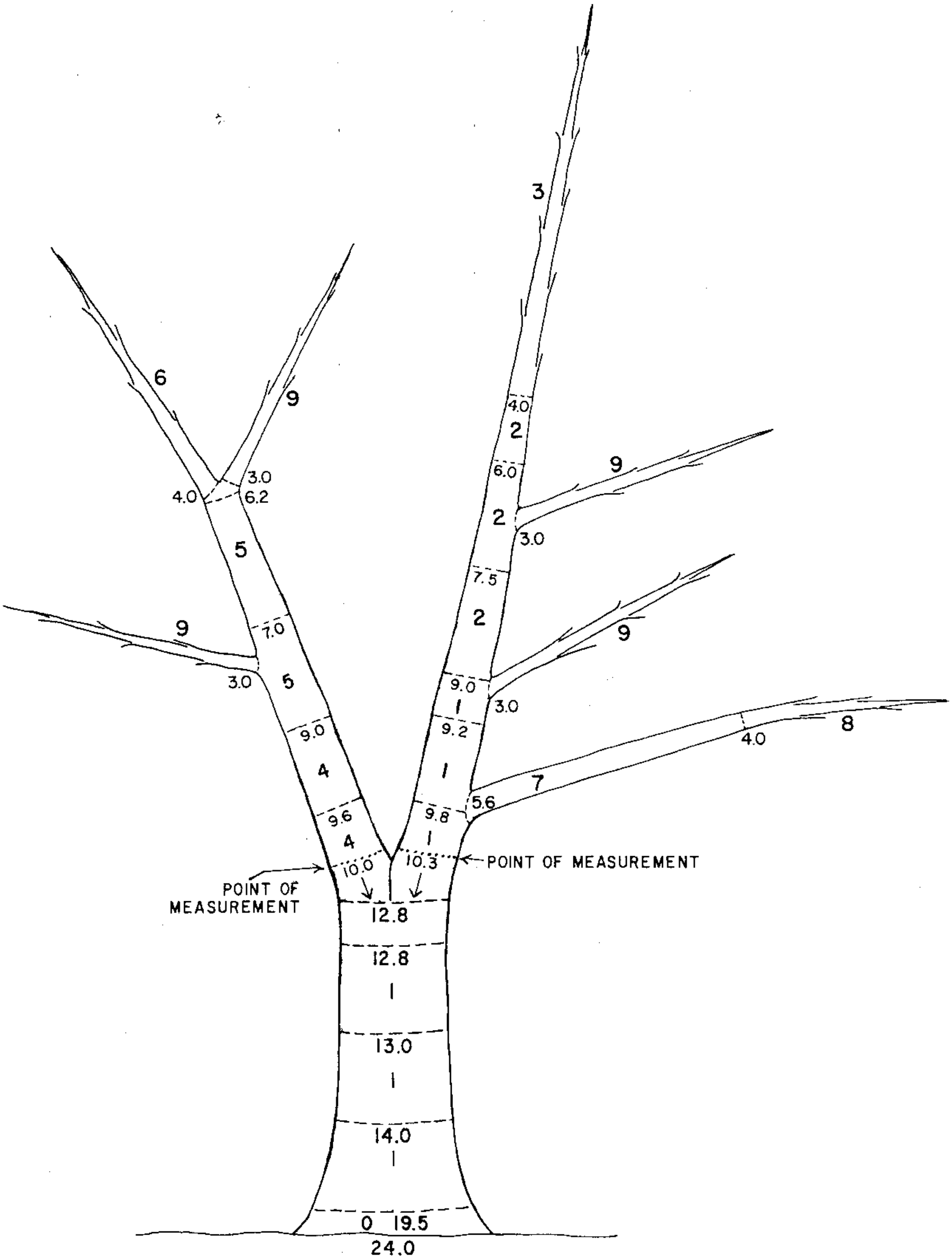

Figure 6.—Sample tree.

$$B_2 = \left[\frac{16.0 - \text{Height above ground}}{9.0}\right]\left[a + b(\text{d.o.b.})\right]$$

thus:

Blended double bark thickness (inches)

$= [B_1 + B_2]$ (b.a.f.)

where:

B_1, B_2 = double bark thickness (inches)

4. The bark thickness equation for a point above 16 feet is:

Double bark thickness (inches)

= [c + d (d.o.b.)] (b.a.f.)

The other programed equations are Grosenbaugh's (1952) formulas for cubic- and board-foot volume (International ¼-Inch Log Rule):

$$\text{Volume } (\text{ft}^3) = 0.005454154 \; L \left[Dd + \frac{(D-d)^2}{K} \right]$$

where:

L = section length (feet)

D = diameter inside bark, large end (inches)

d = diameter inside bark, small end (inches)

K = constant (varies by section identity)

Section identity	*K value*
0	4
1, 2, 4, 5, or 7	3
3, 6, 8, or 9	2.45

$$\text{Volume (fbm)} = 0.04976191\,(Ld^2) + 0.006220239\,(L^2 d) - 0.1854762\,(Ld) + 0.0002591767\,(L^3) - 0.01159226\,(L^2) + 0.04222222\,(L)$$

To compute a net board-foot volume, the defective portion must be deducted from the gross volume. Two formulas are used to calculate the loss due to sweep and crook:

Volume (fbm) (sweep loss)

$$= \left[\frac{(\text{Departure} - \text{Sweep length}/8.0)}{\text{affected section d}}\right] X$$

[affected section gross fbm volume]

Volume (fbm) (crook loss)

$$= \left[\frac{\text{Departure}}{\text{affected section d}}\right] X$$

[affected section gross fbm volume]

OUTPUT DATA

The processing system stores the tree information on magnetic tape. The data on magnetic tape are stored at two levels.

The first level is very detailed. It contains all the basic tree measurements and computed values, by tree section.

Standing or Felled-Tree Section Tape

Fields	*Descriptions*	*Form*
1	Tree indicator	X
2-3	State	XX
4	Unit	X
5-6	County	XX
7-9	Location	XXX
10	Point number	X
11-12	Tree number	XX
13-15	Species	XXX
16-18	D.B.H.	XX.X
19	Log grade	X
20	Crown ratio	X
21	Crown class	X
22-23	Damage	XX
24	Tree class	X
25	Site class	X
26	Tree origin	X
27-28	Physiographic class	XX
29-31	Double bark at d.b.h.	X.XX
32-34	Total age	XXX
35-37	Total height	XXX
38	Number of forks	X
39-40	Sum of major limb diameters	XX
41-42	Product (felled tree only)	XX
43-44	Number of tree sections	XX
45	Ident. 8 or 9	X
46	Survey cycle	X

For each tree section there is:

1	Section indicator	X
2-3	Section number	XX
4	Section ident.	X
5-7	Lower diameter outside bark	XX.X
8-10	Lower diameter inside bark	XX.X
11-13	Upper diameter outside bark	XX.X
14-16	Upper diameter inside bark	XX.X

17-19	Section length	XX.X
20-22	Cubic cull rate	X.XX
23-25	Board-foot cull rate	X.XX
26-27	Number of minor limbs	XX
28-29	Log number	XX
30	Log grade	X
31	Bolter log	X
32	Utilization	X
33-34	Product (felled tree only)	XX
35-37	Double bark top of section (felled tree only)	X.XX
38-41	Sweep and crook loss	XXX.X
42-46	Cubic volume, including bark	XXX.XX
47-51	Cubic volume, excluding bark	XXX.XX
52-56	Net cubic volume	XXX.XX
57-61	Gross board-foot volume	XXXX.X
62-66	Net board-foot volume	XXXX.X

The second level tape that the program produces is a tree summary.

Tree Summary Tape

Fields	*Descriptions*	*Form*
1-2	State	XX
3	Unit	X
4-5	County	XX
6-8	Location	XXX
9	Point number	X
10-11	Tree number	XX
12-14	Species	XXX
15-17	D.B.H.	XX.X
18	Log grade	X
19	Crown ratio	X
20	Crown class	X
21-22	Damage	XX
23	Tree class	X
24	Site class	X
25	Tree origin	X
26-27	Physiographic class	XX
28-30	Double bark at d.b.h.	X.XX
31-33	Total age	XXX
34	Number of forks	X
35-36	Sum of major limb diameters	XX
37-38	Product (felled tree only)	XX
39-40	Number of sections	XX
41	Ident. 8 or 9	X
42	Survey cycle	X
43-44	Optional zone 1	XX
45-46	Optional zone 2	XX
47-48	Optional zone 3	XX
49-52	Merchantable length	XXX.X
53-56	Saw-log length	XXX.X
57-60	Bole length	XXX.X
61-64	Total length	XXX.X
65-67	Stump top diameter outside bark	XX.X
68-70	Merchantable top diameter outside bark	XX.X
71-73	Saw-log top diameter outside bark	XX.X
74-76	Bole-top diameter outside bark	XX.X
77-80	Cubic volume with bark for section ident. 0	XX.XX
81-85	Cubic volume with bark for section ident. 1	XXX.XX
86-89	Cubic volume with bark for section ident. 2	XX.XX
90-92	Cubic volume with bark for section ident. 3	X.XX
93-97	Cubic volume with bark for section ident. 4	XXX.XX
98-101	Cubic volume with bark for section ident. 5	XX.XX
102-104	Cubic volume with bark for section ident. 6	X.XX
105-108	Cubic volume with bark for section ident. 7	XX.XX
109-112	Cubic volume with bark for section ident. 8	XX.XX
113-116	Cubic volume with bark for section ident. 9	XX.XX
117-120	Cubic volume without bark for section ident. 0	XX.XX
121-125	Cubic volume without bark for section ident. 1	XXX.XX
126-129	Cubic volume without bark for section ident. 2	XX.XX
130-132	Cubic volume without bark for section ident. 3	X.XX
133-137	Cubic volume without bark for section ident. 4	XXX.XX
138-141	Cubic volume without bark for section ident. 5	XX.XX
142-144	Cubic volume without bark for section ident. 6	X.XX
145-148	Cubic volume without bark for section ident. 7	XX.XX
149-152	Cubic volume without bark for section ident. 8	XX.XX
153-156	Cubic volume without bark for section ident. 9	XX.XX
157-160	Net cubic volume for section ident. 0	XX.XX
161-165	Net cubic volume for section ident. 1	XXX.XX
166-169	Net cubic volume for section ident. 2	XX.XX

170-172	Net cubic volume for section ident. 3	X.XX
173-177	Net cubic volume for section ident. 4	XXX.XX
178-181	Net cubic volume for section ident. 5	XX.XX
182-184	Net cubic volume for section ident. 6	X.XX
185-188	Net cubic volume for section ident. 7	XX.XX
189-192	Net cubic volume for section ident. 8	XX.XX
193-196	Net cubic volume for section ident. 9	XX.XX
197-201	Gross board-foot volume for section ident. 4	XXXX.X
202-206	Gross board-foot volume for section ident. 1	XXXX.X
207-211	Net board-foot volume for section ident. 4	XXXX.X
212-216	Net board-foot volume for section ident. 1	XXXX.X
217-219	Board-foot cull volume due to internal rot	XXX
220-222	Board-foot cull volume due to jump sections	XXX
223-225	Board-foot cull volume due to sweep and crook	XXX
226-229	Net board-foot volume of grade 1	XXXX
230-233	Net board-foot volume of grade 2	XXXX
234-237	Net board-foot volume of grade 3	XXXX
238-241	Net board-foot volume of grade 4	XXXX
242-246	Net board-foot volume of bolter logs	XXXX.X
247-249	1st upper-stem bark (d.o.b.)	XX.X
250-252	1st upper-stem double bark thickness	X.XX
253-255	2d upper-stem bark (d.o.b.)	XX.X
256-258	2d upper-stem double bark thickness	X.XX
259-261	3d upper-stem bark (d.o.b.)	XX.X
262-264	3d upper-stem double bark thickness	X.XX
265-267	4th upper-stem bark (d.o.b.)	XX.X
268-270	4th upper-stem double bark thickness	X.XX
271-273	5th upper-stem bark (d.o.b.)	XX.X
274-276	5th upper-stem double bark thickness	X.XX
277-281	Net cubic volume in merchantable sections	XXX.XX
282-285	Net cubic volume in upper stem	XX.XX

APPLICATIONS

The primary advantage of this system is that it will work on both standing and felled trees. The system is recommended for: (1) building volume tables, volume equations, and length equations; (2) determining timber sales volume; (3) studying taper rates, limb occurrence, and limb severity; (4) remeasuring trees over a period of time; (5) checking existing volume tables for applicability; (6) building yield tables; (7) checking the length estimating ability of individual cruisers.

Since the identities of all aboveground components of a tree are retained, other uses are possible:

1. Determining the additional yield of fiber that could be expected from stump, crown, limbs, and bark of trees.
2. Relating sizes of tree components to treatments like fertilizer application.
3. Predicting amounts of logging residue by size of material.

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The Forest Service, U.S. Department of Agriculture, is dedicated to the principle of multiple management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forest and Grasslands, it strives - as directed by Congress - to provide increasingly greater service to a growing Nation.