

**Forest Service Handbook
National Headquarters - Washington Office
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**Forest Service Handbook 2409.12a – Timber Volume Estimator Handbook
Chapter 10 - Field Sampling Procedures**

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Date approved:

Responsible Staff:

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Digest: Following is an explanation of the changes throughout the directive by section.

2409.12a: Establishes new Timber Volume Estimator Handbook that provides Service-wide standards and instructions for preparation of equations or tables used to estimate the timber content of trees.

Table of Contents

11 - Organization of the Data Elements.....	3
11.1 - Site and Location Information.....	3
11.2 - Measurement Information	3
11.3 - Tree Information	3
11.4 - Segment Information	3
12 - Required and Optional Data Elements.....	3
13 - Data Field Descriptions, Measurement Standards, and Collection Procedures.....	7
13.1 - Data Fields.....	7
13.2 - Sampling Procedures	18
13.3 - Documentation of Procedures	18
14 - Field Measurements	18
14.1 - Portable Field Recorders.....	18
14.2 - Safety.....	18
14.3 - Measurements Made Before Felling.....	18
14.4 - Measurements Made After Felling.....	19
14.41 - Measurement Points.....	19
14.42 - Diameter.....	21
14.42a - Diameter Measurement	21
14.42b - Logs That Cannot Be Moved	21
14.42c - Stump Diameter	21
14.43 - Bark Measurements	21
14.44 - Height Growth	21
14.45 - Segments	22
14.45a - Cutting the Segments.....	22
14.45b - Cuts Which Fall On a Branch Whorl	22
14.45c - Numbering Segments	22
14.45d - Segment Length	22
14.45e - Breaks.....	22
14.46 - Irregularities	22
14.46a - Missing Pieces.....	22
14.46b - Abnormally Formed Trees	23
14.47 - Before Leaving the Tree.....	23
14.5 - Measurements Made When Trees Are Not Felled	23
14.51 - Types of Equipment.....	23
14.52 - Sighting Points	23
14.53 - Instrument Verification	23
14.54 - Recording Diameters.....	24
15 - Region/Station Modification of Data Elements of Procedures.....	24
15.1 - Modification of Collection Format.....	24
15.2 - Modification of Data Elements.....	24
15.3 - Input of Non-standard Data	24

11 - Organization of the Data Elements

Organize the data collected in standardized groupings as listed in the following sections.

11.1 - Site and Location Information

This information describes the area where the tree grew (FSH 2409.14, Sec. 71.1, 73-77). Use information about area identifiers as well as physiographic characteristics for identification of the data.

11.2 - Measurement Information

Record the information about the methods used to take the measurements and to record the data.

11.3 - Tree Information

Record information that describes the attributes of the standing tree and the area immediately surrounding it. (FSH 2409.14 Sec.71.2).

11.4 - Segment Information

Record information about the diameters, lengths and bark thicknesses for each of the various segments of the tree bole. (FSH 2409.14 Sec.71.2).

12 - Required and Optional Data Elements

Data elements are classed as required or optional and are listed in Exhibit 01. Required elements are indicated by an asterisk in Exhibit 01. Exhibit 02 is a sample field record containing the required and commonly used optional data elements. Use this or an equivalent format which must include the required data elements and may include additional optional data elements.

12 - Exhibit 01

Required (*) and Optional Data

LOCATION INFORMATION

- 1* region
- 2* forest number
- 3* district number
- 4* location ID number
- 5 state
- 6 county
- 7* data source
- 8* X coordinate
- 9* Y coordinate
- 10* UTM zone
- 11* X/Y coordinate system
- 12* date
- 14 site productivity class
- 15 survey cycle
- 16 random number, location
- 17 compartment number
- 18 stand number
- 19 name (comments)
- 121* elevation
- 122 ecological type (habitat type)
- 123 eco/habitat type reference
- 124* aspect
- 125* slope

MEASUREMENT INFORMATION

- 13* measurement system (Eng/Metric)
- 105* crown ratio method
- 116* dia. measurement method

TREE INFORMATION

- 100* sample point
- 101* tree number
- 102* plant species
- 103* dbh
- 104* crown ratio
- 106 crown class
- 107 tree class
- 108 dbh bark thickness (dbh)
- 109* tree height (length)
- 110* number of cuts
- 111 sequence tree number
- 112 accumulated length

12 - Exhibit 01 -- Continued

Required (*) and Optional Data

TREE INFORMATION (cont.)

113	record number
114	sawlog height (merchantable height for sawlogs)
115	sawlog top diameter DIB.
117	17.3' Girard FC
118	33.6' Girard FC
119	assumed stump height
120	random number, tree
121*	elevation
122	ecological type (habitat type)
123	eco/habitat type reference
124*	aspect
125*	slope
126	tree age
127a*	height growth
127b*	height growth interval
128*	radial growth
129	basal area/acre
130	tree top condition
131	ocular tree height
132	percent cull
133	height to crown
134	height to major fork
135	site index
136	site species
137	site index reference

SEGMENT INFORMATION

200*	segment number
201	segment ID (fork code)
202	segment length
203	mid height
204*	DOB ₁
205	DOB ₂
206*	DIB ₁
207	DIB ₂
208*	height of measurement
209	bark thickness ₁
210	bark thickness ₂
211	double bark thickness

13 - Data Field Descriptions, Measurement Standards, and Collection Procedures

13.1 - Data Fields

Data elements are defined in FSH 2409.14, Timber Management Information Systems Handbook. Additional description of each data field, its coding and where applicable, standards and procedures to use are illustrated in Exhibits 01-04. See also the data format, section 12, exhibit 02.

Forest Service Handbook 2409.12a – Timber Volume Estimator Handbook
Chapter 10 - Field Sampling Procedures
Amendment: 2409.12a-1993-1
Effective date: December 23, 1993
13.1 - Exhibit 01

Site and Location Information

- Field 1** Region number/Station number (2-digit numeric).

If Stations are doing the work, use the Station reference number of the Station in which the work is located, not the Region number.
- Field 2** Administrative Forest number (2-digit numeric).
- Field 3** District number (2-digit numeric).
- Field 4** Location ID number (12 characters).

This is a unique identifier for the project. It must be composed of the Region or Station number, plus a number supplied by the Region or Station to make it unique. The additional number may be a combination of Forest, District, and compartment/stand, and entered as a part of the database loading program with field 4 being the Region or Station portion of the identifier.
- Field 5** State (2-digit numeric).
- Field 6** County (3-digit numeric).
- Field 7** Data source (1-digit numeric).

Record one of the listed codes. If your data source is not listed in FSH 2409.14, contact the WO data base coordinator to have it included in the list.
- Field 8** Coordinate (7-digit numeric).

If using Universal Transverse Mercator (UTM) Coordinate system, record the UTM Easting in meters and right justify in the field. For latitude/longitude system, record the longitude in degrees (digits 1-3 of field), minutes (digits 4-5 of field), and seconds (digits 6-7 of field). For state plane coordinate system, record the east-west coordinate in feet, right justified in the field. Be sure to record the state code if state plane coordinates are given.

13.1 - Exhibit 01 -- Continued

Site and Location Information

- Field 9** Y Coordinate (7-digit numeric).
- If using UTM Coordinate system, record the UTM Northing in meters and right justify in the field. For latitude/longitude system, record the latitude in degrees (digits 1-3 of field), minutes (digits 4-5 of field), and seconds (digits 6-7 of field). For state plane coordinate system, record the north-south coordinate in feet, right justified in the field. Be sure to record the state code if state plane coordinates are given.
- Field 10** Universal Transverse Mercator (UTM) Zone (2-digit numeric).
- Record the UTM zone found on United States Geological Survey (USGS) topographic maps.
- Field 11** X-Y Coordinate system (1-digit numeric).
- Field 12** Date (6-digit numeric).
- Record as month/day/year. For example, June 1, 1987 would be recorded as 60187.
- Field 14** Site Productivity Class (1-digit numeric).
- Record a code for the potential cubic feet mean annual increment.
- Field 15** Survey cycle (1-digit numeric).
- Field 16** Random number, location (9-digit numeric).
- This is a computer-generated random number used in selecting subsets of the data.
- Field 17** Compartment number (6-digits numeric). See regional silvicultural examination and prescription handbook or other related regional handbook if available.
- Field 18** Stand number (6-digits numeric). See the regional silvicultural examination and prescription handbook or other related regional handbook if available.
- Field 19** Note text (up to 256 characters).

13.1 - Exhibit 02

Measurement Information

Field 13 Measurement System (1-character).

Record an E for English an M for metric. Consult the national data base coordinator for standards when using metric units.

Field 105 Crown method (1-digit numeric). Record the code which best describes the technique used.

Code Description

- 1 Crown length, compacted (for example, trees with crown on only one side have the crowns mentally shifted to fill in the tree) divided by height of the tree times 100.
- 2 Crown length uncompacted (from tip to lowest live limb) divided by the height of the tree times 100.

Field 116 Diameter measurement technique (1-digit numeric).

Record the code for the technique describing the way the section measurements were made.

Field 100 Sample point (4-digit numeric).

If the sample is from a design where sample point has no meaning, record a 1; otherwise, record the sample point number.

Field 101 Tree number (4-digit numeric).

Tree number, combined with the 12-character location identifier and point number, uniquely identifies the tree. The number cannot be duplicated anywhere on the point.

Field 102 Plant Species code (5 characters). See Interim Resource Inventory Glossary.

Record the species code as shown in FSH 2409.14. For example, lodgepole pine is PICO.

Field 103 Diameter at breast height (dbh) (4-digit numeric).

Record the dbh in inches and tenths of inches. Measure with a diameter tape felling the tree.

Field 104 Crown Ratio (3-digit numeric).

Record a code corresponding to the percent of live crown.

Field 106 Crown class (1-digit numeric).

Record the code for the crown class of the tree.

Field 107 Tree Class (1-digit numeric).

Record the code which describes the class of tree.

Field 108 Double bark thickness at dbh (3-digit numeric).

Record the double bark thickness in inches and tenths of inches. The preferred method of determining this value is to measure the outside bark diameter at the dbh cross section, then measure the inside bark diameter and subtract the two readings to get the bark thickness. When a section cut is not made at dbh, a hatchet may be used, or as a last resort bark gauge. Ensure this measurement is not taken in the bark fissures or where abnormalities occur.

13.1 - Exhibit - 03 -- Continued

Tree Information

Field 109 Tree Height(length) (4-digit numeric).

Measure the standing tree height using an appropriate instrument. This measure is ground to tip. It may be desired for smaller trees to record this value to the nearest one tenth foot or centimeter. If the standard field form is used, specify the decimal.

Field 110 Number of section cuts (2-digit numeric).

Count the number of places where cross-section information was taken, including the stump and top, and record that number. Use this field as an edit check to ensure all of the segment data have been accounted for.

Field 111 Sequence number (9-digit numeric). Leave blank.

This is a variable which is generated by the data base software and is useful in finding a particular record in a file of records.

Field 112 Accumulated height (length) (4-digit numeric).

This field is used to edit the segment data. Starting from the ground, the segment heights (lengths) are added together. If this value is drastically different from the standing tree height, an error message may occur on database loading.

Field 113 Record number (6-digit numeric). Leave blank.

This value is generated by the data base software.

Field 114 Sawlog height (sawlog length) (4-digit numeric).

Record the height to a user-specified top diameter.

Field 115 Sawlog top diameter inside bark (3-digit numeric). Measure in inches and tenths of inches at the point field 114 was measured.

Field 117 Girard form class at 17.3 feet (2-digit numeric).

Record the Girard form class value for top of the first 16 foot log. Girard form class is calculated:

$$[\text{DIB (17.3')} \times 100] / \text{DBH}$$

13.1 - Exhibit 03 -- Continued

Tree Information

Field 118 Girard form class at 33.6 feet (2-digit numeric).

Record the Girard form class value for top of the first 32 foot log. Girard form class is calculated:

$$[\text{DIB (33.6')} \times 100] / \text{DBH}$$

Field 119 Assumed stump height (3-digit numeric).

In some felled tree studies, the measurements recorded may start at stump height. Actual stump height varies; however, there may be a targeted stump height, such as 1 foot. In this case, record the assumed stump height in feet and tenths of feet.

Field 120 Random number, tree (9-digit numeric). Leave blank.

This number is generated by data base software and is useful for selecting subsets of the data.

Field 121 Elevation (5 digit numeric).

Record the height above sea level referencing topographic maps. This is for the location of the tree, not the elevation of the study as a whole. 3501 feet would be recorded as 3501.

Field 122 Ecological Type (Habitat Type).

Record the code used by the Region or Station to reference the Habitat, Ecoclass, and Vegetation type for the area immediately surrounding the tree in question.

Field 123 Ecological Type (Habitat Type) reference code (2-digit numeric) which describes the Habitat/Ecoclass reference.

Other habitat classifications may be added to the list and assigned a code by the data base coordinator.

Field 124 Aspect (3-digit numeric) azimuth in degrees for the area immediately surrounding the tree in question. Record North as 360, not zero. Record flat ground as 999.

13.1 - Exhibit 03 -- Continued

Tree Information

- Field 125** Slope (3-digit numeric) in percent for the area immediately surrounding the tree in question. Record flat ground as 999.
- Field 126** Tree Age (4-digit numeric) at breast height.
- Field 127a** Height Growth (3-digit numeric).
- For selected conifers where annual height growth can be measured, record the height growth for a user assigned number of growing seasons. Measure in feet and tenths of feet.
- Field 127b** Height Growth Interval (2-digit numeric).
- Count the number of growing seasons in the height growth interval.
- Field 128** Radial Growth (3-digit numeric).
- For selected trees where diameter growth can be measured by ring counts, record the value for the last 10 years in 20th's of an inch. For example, a tree growing 3.5 inches in diameter would have a recorded value of 35.
- Field 129** Basal area per acre (3-digit numeric).
- Record the average basal area per acre for the area surrounding the tree being measured. This may be derived as the result of an area wide exam or from installing a prism point with the tree in question as the approximate center. Do not count the tree to be felled.
- Field 130** Tree Top Condition (1 character).
- Record a code for top damage to the tree (sec. 71 FSH 2409.14).
- Field 131** Percent cull (3-digit numeric).
- Record the defect amount to the nearest whole percent based on an ocular estimate. (Use a reference to a percent volume breakdown by log for both scribner and cubic measure).
- Field 132** Height to Crown, Uncompacted (3-digit numeric).

13.1 - Exhibit 03 -- Continued

Tree Information

Field 133 Height to fork (3-digit numeric).

Record the distance from the ground to the fork in the bole. See FSH 2409.12 for measurement procedures.

Field 134 Site Index (3-digit. numeric) for the area surrounding the tree being measured.

Field 135 Site species (5 characters).

The species code for the species on which the site index curves were constructed for calculating the site index recorded in field 135. Use the same species codes as are used for field 102.

Field 136 Site index reference (3-digit numeric).

Record the code for the reference document used to find the site index recorded in field 134. Other site references may be added to the list and assigned a reference code by the data base coordinator.

13.1 - Exhibit 04

Segment Level Information

Field 200 Segment number (2-digit numeric).

Record a unique number for each segment in the tree. See sec. 14.45c.

Field 201 Segment ID (3 characters alpha/numeric).

Record an identifier for each segment. Use this data element for forked trees. Code the main stem as straight segment numbers 1,2,...n. Forks would have a label in field 201 as F1, for the first fork; F2, for the second fork, and so on.

Field 202 Length (3-digit numeric).

Record the length of the segment in feet and tenths of feet.

Field 203 Mid height (4-digit numeric).

Record the height from the ground to the middle of the segment. Measure in feet and tenths of feet.

Field 204 DOB₁ (4-digit numeric).

Record the first of 2 diameter outside bark measurements, top of the segment, in field 204. Measure in inches and tenths of inches. If only one outside bark measure is made, record in this field. For illustrations on how to treat odd shaped pieces, refer to the Timber Cruising Handbook, FSH 2409.12 and the Cubic Scaling Handbook, FSH 2409.11a.

Field 205 DOB₂ (4-digit numeric).

Record the second of 2 diameter outside bark measurements, top of the segment. Measure in inches and tenths of inches. The second measurement should be taken at right angles to DOB₁.

Field 206 DIB₁ (4-digit numeric).

Record the first of 2 diameter inside bark measurements, top of the segment. If only one measure is taken, record it in this field. Measure in inches and tenths of inches.

13.1 - Exhibit 04. -- Continued

Segment Level Information

Field 207 DIB₂ (4-digit numeric).

Record the second of 2 diameter inside bark measurements, top of the segment. Measure in inches and tenth of inches. Like Field 205, this second measurement of diameter should be at right angles to the first measurement.

Field 208 Height of measurement (4-digit numeric). Measure in feet and tenths of feet from the ground to the top of the segment being recorded.

Field 209 Bark thickness₁ Single bark thickness₁ (2-digit numeric). Record bark thickness at the location of DIB₁ and DOB₁ measurements. Measure in inches and tenths of inches.

Field 210 Bark thickness₂ (2-digit numeric). Record bark thickness at the location of DIB₂ and DOB₂ measurements. Measure in inches and tenths of inches.

Field 211 Double bark thickness (3-digit numeric).

If only one bark measure is available. Record the double bark thickness in this field in inches and tenths of inches.

13.2 - Sampling Procedures

A variety of sampling procedures may be used. See the FSH 2409.12, Timber Cruising Handbook or appropriate references on sampling and select an appropriate procedure.

13.3 - Documentation of Procedures

Prepare a stem profile project synopsis which describes sample design, selection criteria, and field instructions. This synopsis will be an aid to users of the profile data that were not directly involved in the project and will minimize misuse or inappropriate use of data.

14 - Field Measurements

Select normal trees with a single bole that have no evidence of major current or past damage for the purpose of obtaining data for volume estimators. Basic field procedures for measurements are contained in the Timber Cruising Handbook (FSH 2409.12). Data elements needed for stem profiles are given in previous sections 12-13.1. Additional direction for the field measurements needed for volume estimators is contained in the following sections.

14.1 - Portable Field Recorders

Use field data recorders whenever available for recording the measurements. Arrange for field recorder software procurement and maintenance that meets the standards of this handbook (sec. 11.1 - 14.54).

14.2 - Safety

Taking stem profile measurements in the field and on felled and bucked trees presents potential safety hazards. Ensure that field crews are properly equipped (non-slip boots, hard hats) and are instructed in safe procedures for traveling to the work site and for measuring, felling, and bucking trees. Review appropriate sections of the Health and Safety Code Handbook, FSH 6709.11 prior to initiating the project. Do not sample trees that cannot be felled, bucked, or measured safely.

14.3 - Measurements Made Before Felling

Measure and record the following information while the tree is standing.

Forest Service Handbook 2409.12a – Timber Volume Estimator Handbook

Chapter 10 - Field Sampling Procedures

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14.3 - Table 01

Measurements Made Before Felling the Tree

Diameter Breast Height (dbh)
Total Height (Length) (Ground to tip as described in Field 109)
Sawlog Height (Length) to merchantable sawlog top
Crown Ratio
Height to Crown, Uncompacted
Girard form class 16 or 32 feet
Site information
Slope
Aspect
Elevation
Ecological Type (Habitat Type)
Site index, species, reference table
Location and other ID information
Height to fork
Tree number (painted on the bole)
Basal area/acre
Percent cull

14.4 - Measurements Made After Felling

Measure each tree after it has been felled according to the directions in the following sections.

14.41 - Measurement Points

Take specific measurement at stump height, at a point between stump height and 4.5 feet, at 4.5 feet (breast height), at the form class point (either 16 or 32 feet), at the base of the crown, and at each top diameter outside bark of 5", 4", and 3". As a general rule, take a minimum of measurements at points equal to ten percent of the tree's height. Exhibit 01 illustrates a hypothetical tree with buck points.

Forest Service Handbook 2409.12a – Timber Volume Estimator Handbook

Chapter 10 - Field Sampling Procedures

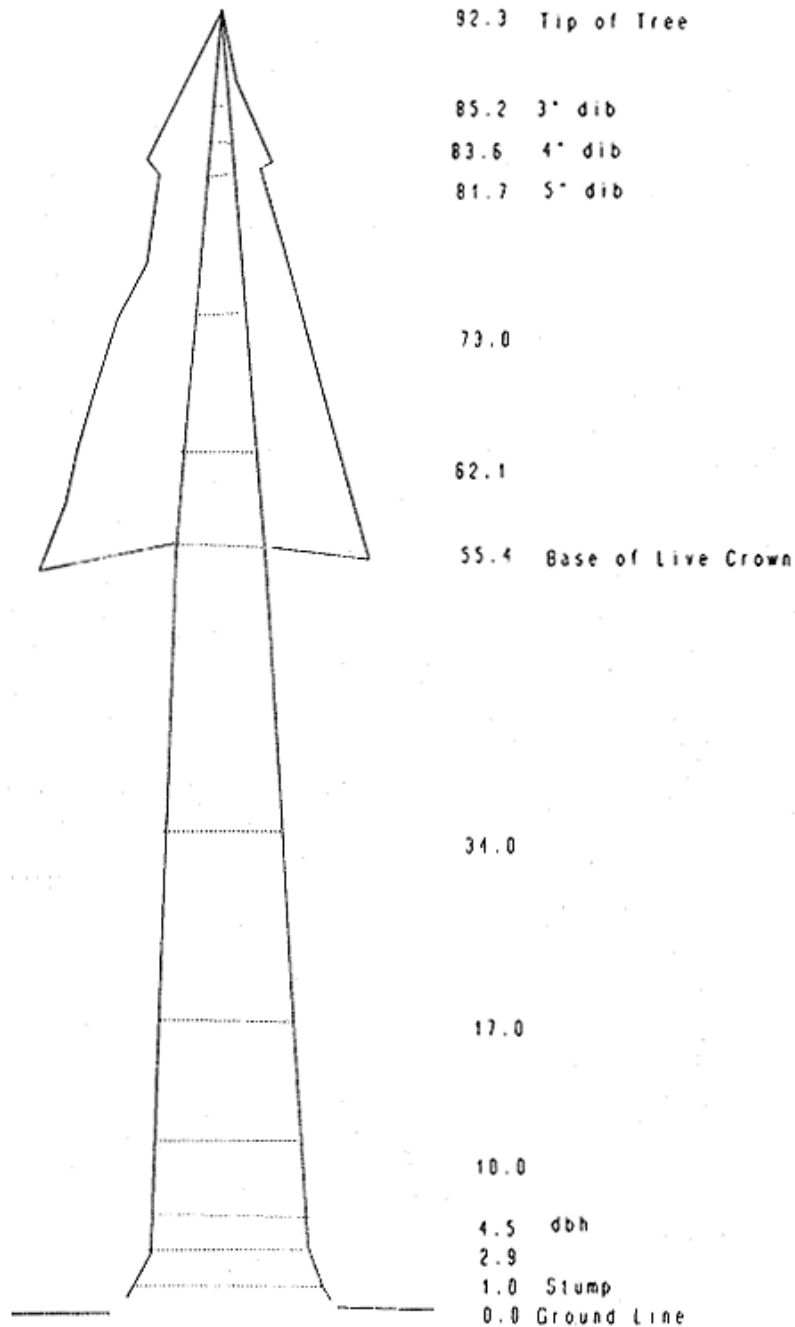
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Effective date: December 23, 1993

14.41 - Exhibit 01

14.41 - Exhibit 01

Points of Measurement on Typical Tree



14.42 - Diameter

When there is a choice between using a caliper or actually bucking the tree and recording a cross section area, bucking before measurement should be used since bark thickness can be determined more accurately with a bucked log.

14.42a - Diameter Measurement

When only one measurement is taken, it should be the average diameter as if taken with a diameter tape. If two measurements are taken, one should be the short axis and the other should be perpendicular to the short axis. When both inside and outside diameters are recorded, calculate bark thickness by subtraction.

14.42b - Logs That Cannot Be Moved

If log is pinched, too big, or unsafe to move, use a caliper to measure the diameter. Use a diameter tape to measure the diameter where the end cannot be seen.

14.42c - Stump Diameter

Measure the stump diameter after the tree is felled Using the same instrument as Used for the other segments. Make this measurement at the first place where a full circumference can be obtained in the case where an under cut makes for an uneven stump surface.

14.43 - Bark Measurements

Make bark measurements with a bark gauge or by subtracting the diameter inside bark from the diameter outside bark. Either method may be used. If bark thickness is to be calculated by subtraction, record the inside and outside bark diameters. The data computation program should calculate the bark thickness.

For felled tree studies, take bark thickness measures at each measurement point. If a bark gauge is used, the measurement can be single bark thickness and so indicated on the field sheet. The double bark thickness is calculated by the data computation program.

14.44 - Height Growth

Count five full growing seasons back from last year's whorl. Cut the tree at the fifth whorl and count the number of rings. Record this value in the height growth interval field on the field form. Measure the distance from the cut to the last year's whorl and record the value in feet and tenths of feet. Be sure to look for past top damage. If the interval is other than 5 years, record the actual number of rings in the height growth interval field; if 10 years, record 10. Additional detail may be found in the Interim Resource Inventory Glossary and in FSH 2409.14, chapter 70.

14.45 - Segments

14.45a - Cutting the Segments

Cut the bole at each point where diameter measurements are needed. Ensure that field crews follow appropriate safety procedures for bucking. (sec. 14.2 and 14.41).

14.45b - Cuts Which Fall On a Branch Whorl

Since the diameter measurements should not get bigger as the height above ground increases, avoid bucking the tree on a whorl or limb swell to minimize the occurrence of swell points. If a cut must take place on a whorl or limb swell, the axis must not include a knot.

14.45c - Numbering Segments

Starting from the stump, which is segment 1, number each segment by placing the proper number on each segment at the small end.

14.45d - Segment Length

Measure the distance (height or length) from a diameter measure point to the next diameter measure point with a tape.

Use a tape calibrated in feet and tenths of feet, not feet and inches. Start measuring from the ground on the high side and work up the tree. The first segment is from the ground on the high side to top of stump. Most stumps have an uneven surface. Pick the highest surface but ignore stump pulls, barber chairs, and splinters. Match the place of measurement with the same place on the second segment. Continue this practice up to the tip of the tree. Ensure that the sum of the segments equals the height of the tree from ground to tip.

14.45e - Breaks

If the tree breaks when it is felled, visually put the tree back together when measuring segment lengths. The break may or may not be considered a buck point. The choice depends on the particular study. For example, if the study is linked to a particular log scaling rule, buck according to instructions for that rule. See FSH 2409.11 for the Scribner rule or FSH 2409.11a for the cubic rule.

14.46 - Irregularities

14.46a - Missing Pieces

Trees should be rejected from the sample if a piece is missing. To avoid unnecessary measurement, inspect the bole for its full length before taking measurements. If the tree has missing parts, reject the tree.

14.46b - Abnormally Formed Trees

Do not use trees with forks in the main bole, excessive sweep, and crook for stem profile work. Handle forks, crook, and sweep as defect corrections. This includes trees with forks below diameter breast height.

14.47 - Before Leaving the Tree

Edit the data sheet or field data recorder information before leaving the tree and ensure that all required fields are completed. Add the segment lengths and ensure they equal the total height of the tree. Outside bark diameters normally decrease as they progress up the bole; check for errors and confirm any abnormality. Ensure that each set of field instructions mandates these and other field edits deemed to be important for the study or the location.

14.5 - Measurements Made When Trees Are Not Felled

Use optical segmentation procedures for upper stem segment diameters on standing trees in studies where trees are not felled. Measure remaining portions of the tree as described in section 14.3.

14.51 - Types of Equipment

Use the Barr and Stroud Dendrometer, the Spiegel Relaskop with telescope, or laser cruising device to optically determine upper stem diameters. Do not use the Wheeler Pentaprism. For technical instructions on how to use these instruments refer to the manufacturer's user manuals. Use a tripod capable of fine adjustment to support the instrument while measurements are taken.

14.52 - Sighting Points

As with felled tree work, make a minimum of 10 sighting points (measurements points) on the tree. Include stump, diameter breast height, form class point, base of live crown, and at least two sightings between 6" diameter outside bark and the tip. For the remaining sightings, distribute sighting points as evenly along the bole, as possible, but choose areas of opportunity where visibility is good. See section 14.41 for additional information on measurement points.

14.53 - Instrument Verification

Before taking readings with the instrument, measure the diameter breast height (dbh) with a diameter tape. The first instrument sighting should be at dbh. If the instrument value is significantly different from the tape measurement one of the following will likely be the cause:

1. The bole is excessively elliptical. Reject the tree.
2. The instrument is misadjusted. Adjust the instrument.
3. The instrument is misread. Instruct the instrument person on proper procedure.

4. The distance to the tree may have been misread. Remeasure the distance from instrument to tree.

Make the last measurement a second reading on dbh, providing a way to check if the tripod settled or was tilted while the work was being done. If the second dbh is substantially different from the first, check for error in recording. If none is found, reset the tripod and remeasure the tree.

14.54 - Recording Diameters

Dendrometers, tele-relaskops, and laser instruments may not read diameters directly. Follow instructions for the instrument of choice and the hand held calculator programs available to convert these readings to diameters in the field. Record the field values for diameter in inches and tenths of inches, and the height in feet and tenths of feet. Do not record the instrument values rather than the diameters.

Set up the instruments so the vertical angles are less than 45 degrees. Do not select trees to be measured with the optical instruments if the vertical angle of the instrument exceeds 45 degrees.

Check all field data for completeness, accuracy, and legibility before moving the instrument and before leaving the tree. Incongruities in instrument values discovered later in the office when the diameters are calculated are not correctable since the tree is no longer available for rechecking.

15 - Region/Station Modification of Data Elements of Procedures

15.1 - Modification of Collection Format

If modification of the data collection format (sec. 12) is made, verify applicability of the national data loading and edit programs, then modify or replace them as necessary to ensure consistency with data already in the data base.

15.2 - Modification of Data Elements

Do not change definitions of data elements (FSH 2409.14, Ch. 70). Additional descriptive information may be prepared and used in field instructions. If an entirely new element is needed, follow the procedure for non-standard data (sec. 15.3) and request appropriate approval (sec 04.1) for modification of the glossary in FSH 2409.14.

15.3 - Input of Non-standard Data

When the input of previously collected, old, or unique data sets into the felled tree data base is necessary, develop the custom software needed to load the data and work closely with the designated data base coordinator (sec. 04.13). Ensure the data is consistent with existing standardized data.