

**Forest Service Handbook  
National Headquarters - Washington Office  
Washington, DC**

**Forest Service Handbook 2409.12b – Timber and Forest Products Trespass/Theft Procedures  
Handbook  
Chapter 20 - Measurements**

**Amendment:** 2409.12b-2012-1

**Effective date:** August 16, 2012

**Duration:** This amendment is effective until superseded or removed.

**Approved by:** James M. Pena, Associate Deputy Chief, NFS

**Date approved:** August 10, 2012

**Responsible Staff:**

**Last Change:** None

**Superseded Document(s):**

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

**2409.12b:** Establishes new handbook “FSH 2409.12b, Timber and Forest Products Trespass/Theft Procedures Handbook.”

**Zero Code:** Establishes handbook and sets forth direction on procedures for preventing and investigating trespass and theft of forest products. In addition to consolidating information scattered throughout several different manuals and handbooks, it clarifies existing direction and provides new direction for the prevention of or the investigation of trespass and/or theft of forest products.

**10:** Establishes chapter 10 and sets forth direction on procedures to address the prevention, discovery, legal concerns, and reporting for timber and forest products trespass and theft.

**20:** Establishes chapter 20 and sets forth direction on procedures to conduct timber measurements for timber and forest products trespass and theft.

**30:** Establishes chapter 30 and sets forth direction on procedures for valuation and appraisal method(s) for timber and forest products trespass and theft.

**40:** Establishes chapter 40 to set forth procedures for the sale and disposal of seized material from timber and forest products trespass and theft.

**Table of Contents**

<b>20 - Requirements for Theft or Trespass Measurements.....</b>	<b>4</b>
<b>20.1 - Log Scaling Procedures .....</b>	<b>5</b>
<b>20.2 - Comparison Cruise Method .....</b>	<b>9</b>
<b>20.3 - Combined Scale and Comparison Cruise .....</b>	<b>14</b>
<b>20.4 - Local Volume Tables.....</b>	<b>16</b>

## 20 - Requirements for Theft or Trespass Measurements

Each theft or trespass requires special consideration depending on the circumstances involved. The following requirements apply to all measurements:

1. A certified Advanced Cruiser (FSM 2442.03) or certified Scaler (FSM 2443.04b) shall supervise the taking of measurements.
2. A certified Scaler shall measure logs following the procedures outlined in section 20.1.
3. If only stumps are present, a certified Advanced Cruiser shall follow the guidelines outlined in section 20.2.
4. Inventory all stumps. Do not use variable plot or sample tree cruise methods to sample for stumps. See section 20.2 for situations where a fixed plot cruise may be used in lieu of a 100 percent inventory.
5. Mark the top of all stumps with tracer paint and number stumps with either tracer paint or numbered metal tags for future reference to the field cruise records. Do not use a paint color present in the area. If the theft or trespass occurred in an area that had been either cut tree or leave tree marked, considerable care must be taken to not paint the sides of stumps as this could cover or taint evidence of those marks.
6. Brand all material measured as theft or trespass volume with a "US" brand.
7. Coordinate with Law Enforcement on taking photographs concurrent with marking and measuring timber. Record date, time, and location where each photo was taken, along with the name of the person taking the photos and any other information requested by Law Enforcement.
8. For forest products other than timber, document the unit of measure (pounds, bushels, each) and method(s) used to determine quantities of material.
9. Prior to initiating field work, consult the regional appraisal specialist for valuation methods that will be used to determine if any additional data needs to be collected. For example, identifying where special methods will be needed to remove logs and/or slash from streams and riparian areas. See chapter 30, Valuation of Theft and Trespass Material, for valuation methods.

Document all pertinent facts regarding the theft or trespass in a daily diary. Write clear legible notes. This diary may be used in court proceedings. Important items for daily entry should include but are not limited to:

1. Project name.

2. Date.
3. List of team members including their certifications and duties.
4. Unit or area and legal description.
5. Weather.
6. Cruise or scale data may be documented in the diary or a data recorder and at a minimum should include:
  - a. Stump or tree number assigned.
  - b. Species.
  - c. Stump diameter and height at which diameter taken.
  - d. Green or dead and how determined.
  - e. Photograph before and after numbering stumps logs, or trees.
  - f. Tracer paint color, lot and batch numbers, and field test results.
  - g. If trees and/or stumps in the trespass or theft area were previously painted document colors found results of field tests for tracer element.
  - h. Time of day.

If the data is kept separately, the Scaler/Cruiser shall date and sign each page. Note all facts pertinent to an investigation in the diary. The Cruiser or Scaler should keep a sketch map of stump or tree locations. A Global Positioning System map or a conventional survey system map should be made of all stumps if the area is extensive.

### **20.1 - Log Scaling Procedures**

Scaling should be the first choice of measurement. If qualified Scalers are not available, consider getting help from another region and/or contracting with a qualified Scaler. The following procedures must be used when scaling methods are applied:

1. Scaling must be done by Scalers certified at the production level or higher as defined in FSH 2409.15.
2. Establish the area of the theft or trespass.
3. Take measurements on each log as described in FSH 2409.11 or FSH 2409.11a.
4. Follow log grading procedures for the region or area where the trespass or theft occurred, keeping in mind the characteristics needed to support the highest possible

valuation may be needed to conduct an appraisal. Scaling instructions should identify the products to be scaled, such as lumber, veneer, shakes, and music wood.

5. Where only partial sections of the tree have been removed and the remainder of the tree is still present, keep measurements of the removed sections and the remaining sections separate.
6. Document damage to the residual stand. This may involve cruising the damaged trees, locating and measuring broken tops, and taking photographs to document the damage.
7. Average defect for similar species may be applied. Do not make defect deductions for breakage due to falling or yarding.
8. Record merchantable volume left in tops, high stumps, and unused logs separately.

When only stumps or tops are present and/or the logs from a tree are missing and cannot be scaled use the following log reconstruction method in lieu of the comparison cruise method described in section 20.2, if it yields a more accurate volume:

1. Stamp and number the stump using methods described in section 20.
2. Locate the top of the tree and measure the diameter where the last log was bucked.
3. Measure the distance from the stump end to the top and convert this distance to number of logs according to the common bucking practice for the area, considering trim. Holes or depressions in the ground may help to locate where the butt rested. Sawdust helps to show the length of logs where they were bucked and can be used in place of the common bucking practice for determining log lengths.
4. Establish the diameter at breast height (DBH) by comparison with adjacent trees or approved tables.
5. Obtain diameter inside bark (DIB) at the top of the first 16-foot log by use of DBH and average form class for the stand.
6. By use of taper tables, establish the diameter of all the logs obtained in step 3.
7. Record length and diameters of these logs, identify by stump number. Determine the volume for each log and make deductions for defect on the basis of what is seen in the stump, top, or any cull logs left.
8. Volume tables based on DBH and the numbers of logs are sometimes used to estimate volume, eliminating the need to estimate log diameters. Refer to section 20.4 for more information. An example of the log reconstruction method can be found in exhibit 01. If stumps and other evidence are lacking but scalable logs exist on the site, refer to chapter 20 of this handbook for further guidance.

**Chapter 20 - Measurements**

**Amendment:** 2409.12b-2012-1

**Effective date:** August 16, 2012

Use extreme care in scaling timber, especially by a stump scale, and keep complete accounts and legible notes of the methods used. This information may be needed as legal evidence in court. Take photographs as requested by the Law Enforcement Officer in charge.

Chapter 20 - Measurements

Amendment: 2409.12b-2012-1

Effective date: August 16, 2012

20.1 - Exhibit 01

**Log Reconstruction Example  
(16-foot maximum scaling length)**

Stump Number = 1

Distance from stump end to top = 86 feet

Top diameter = 8 inches

Stump Diameter = 30 inches

DBH = 26 inches

Average form class = 80.

DIB at top of first 16-foot log = 21 inches (80 percent of 26 inches).

Number of logs = 6

four 16-foot, one 10-foot, and one 8-foot (6 inches of trim per log)

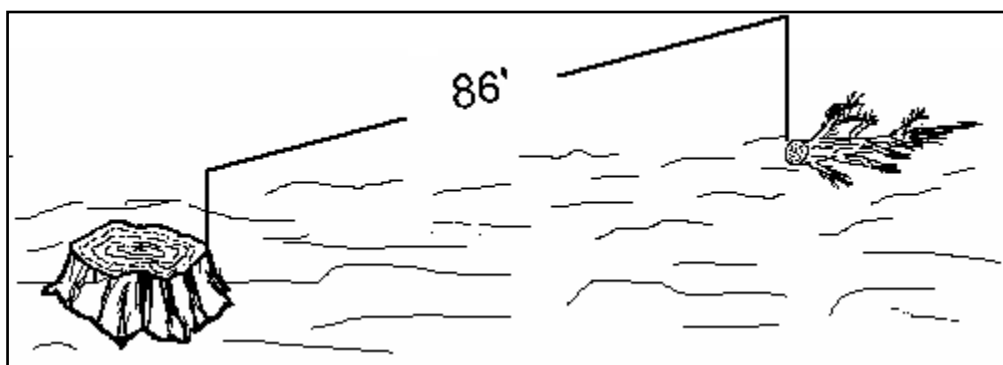
Taper = 13 inches

Diameter of first log – diameter of top =  $21 - 8 = 13$ .

A taper table provided the following log diameters: 21, 19, 16, 13, 11, and 8 inches.

Record Logs.

Log	Length	Small Diam	Volume (Scrib. Dec. C)
1	16	21	30
2	16	19	24
3	16	16	16
4	16	13	10
5	10	11	4
6	8	8	1
Total			85





## 20.2 - Comparison Cruise Method

Apply the comparison cruise method to theft or trespass cases where the majority of the material has been removed from the site and reconstructing logs is not an option. For example, the remaining tops and logs have been moved and scattered and can no longer be matched to a specific stump. Refer to exhibit 01 for comparison cruise data.

The comparison cruise method uses data from standing trees in the immediate stand or adjacent stands to determine the volume of material removed. Determine average volume per tree or develop regression equations and apply the average volumes or regression equations to each measured stump in the area.

The first step in the comparison cruise method is to complete a stump cruise with certified cruisers following these guidelines:

1. Identify and measure every stump. Under certain circumstances, such as large areas or heavy slash, sampling for stumps using fixed plots may be used (FSH 2409.12, ch. 34).
2. Determine the highest common stump height from the high ground side. For example, if the stumps have been cut between 6 inches and 12 inches from the ground, the highest common stump height is 6 inches so measure all the stump diameters at 6 inches above the ground on the high side. In some situations, the common stump height may be at ground level measured from the high side. The common stump height provides a common index to base correlations with standing trees.
3. Determine and record the species of each stump.
4. Measure stump diameters outside bark at the highest common stump height from the high ground side. Measure all stump diameters in a consistent manner, either to the nearest 0.1 inch, or round diameters to the nearest one inch class.
5. Document all the procedures used. Take photographs as requested by Law Enforcement.

The next step is to complete a comparison cruise. If the trespass or theft involves less than 50 trees with little variation in stump diameters, the average volume method is appropriate. Otherwise, regression analysis techniques will be required to determine the volume of material removed.

For the average volume method:

1. Select three to five standing trees per stump diameter class and stump species in the immediate stand or from adjacent stands if necessary.
2. Measure each standing tree and record the information needed for determining volume (diameter, height, defect, number of logs, and so forth) as done for a normal timber

cruise, and any additional information that may be needed to determine value using the methods in chapter 30. All standing tree information must be collected by a certified cruiser.

3. Provide maps showing the comparison cruise area in relation to the theft or trespass area and document the procedure for determining sample trees (closest to stump and fixed plots). If possible, take pictures of the theft or trespass area and the comparison cruise area.
4. Determine the average volume for each species stump diameter class.
5. Apply the average volume for each species stump diameter class to the appropriate species stumps to determine the volume associated with each stump.

For regression analysis method, the comparison cruise will provide data to develop regression equations for each appraisal item's relationship to stump diameter. The comparison cruise data should be collected from the standing trees in the immediate stand if a sufficient sample can be obtained. Cruise adjacent stands if necessary. Keep each species as a separate population. If trees involved are of a specific size, limit the comparison cruise to individual trees of like size. If a wide range of material is involved, the comparison cruise should encompass trees across the complete size range for each species. All standing tree information needs to be collected by a certified cruiser. For the regression method, use the follow steps:

1. Define the populations for the comparison cruises (species and size ranges). If you have multiple species, you will need multiple comparison cruises.
2. Select the comparison cruise trees in an unbiased manner. This can be accomplished by selecting every tree in the population falling within some predetermined area or using plot cruising methods to determine the sample trees (FSH 2409.12). Document your sampling procedures and provide maps showing the comparison cruise area in relation to the theft or trespass area. If possible, take pictures of the area and the comparison cruise area.
3. For each selected comparison cruise tree, measure the information using common cruising practices for the area for a normal timber cruise (DBH, total height, and defect assessments).
4. Record the stump diameter at the common stump height determined from the stump cruise. Begin a comparison cruise only after determining this stump height.
5. Collect an adequate sample size for each identified population. As a rule of thumb, 30 comparison cruise trees is considered an adequate sample size in most cases. If the population you are sampling is highly variable (such as, lots of defect, tree height varies greatly within diameter classes) and the range of diameter classes is large, more trees will need to be sampled.

**Chapter 20 - Measurements**

**Amendment:** 2409.12b-2012-1

**Effective date:** August 16, 2012

6. For each appraisal item, develop a regression equation correlating the appraisal item to stump diameter. Common appraisal variables include DBH, height, gross volume, net volume, and number of merchantable logs. Refer to a mensuration text book for examples of regression equations. Obtain help or mensurational advice if uncertain how to proceed.
7. Maintain all regression output and reports. The relationships between the appraisal variables and stump diameter must be explainable in a court of law.
8. Apply the regression equations to the appropriate measured stumps to determine the appraisal values for each stump.

Chapter 20 - Measurements

Amendment: 2409.12b-2012-1

Effective date: August 16, 2012

20.2 - Exhibit 01

Comparison Cruise Data

Tree Number	Species	Stump Diameter (D)	DBH	Total Height	Cubic Volume
1	LP	16.4	13.9	54	22.5
2	LP	17.7	14.1	65	29.7
3	LP	10.3	8.2	41	4.4
4	LP	10.8	8.3	42	5
5	LP	14	11.8	65	19.7
6	LP	14.6	11.1	62	16.8
7	LP	18.1	13.9	60	24.2
8	LP	9.8	8.7	53	7.1
9	LP	12.6	9.9	44	8
10	LP	9.7	7.3	41	2.3
11	LP	10.9	9.9	45	8
12	LP	11.9	11	60	15.3
13	LP	11.7	9.2	57	10.1
14	LP	20	14.7	77	40.1
15	LP	19.4	15.6	77	41.4
16	LP	9.6	8.3	45	5
17	LP	21	15.6	60	32.7
18	LP	24.9	18.5	79	64.8
19	LP	28.6	22.2	76	88.2
20	LP	26.8	21.9	76	84.3
21	LP	23.1	17.1	75	52.3
22	LP	22.3	17.3	76	55.1
23	LP	13.5	11.3	65	18.1
24	LP	11.7	9.5	46	8
25	LP	12.1	9.9	56	10.7
26	LP	9.8	8.3	41	4.4
27	LP	10.5	8.2	51	6
28	LP	9.7	8.2	42	4.4
29	LP	15.7	11.9	70	21.2
30	LP	18.5	15	64	31.3
31	LP	19.9	16.5	71	45.1

Results from a regression analysis using the above listed data.

$$DBH = 1.001498 + 0.733636 * D$$

Sample Size = 31; R<sup>2</sup> = 0.976; Mean Square Error = 0.4208

$$Total\ Height = -0.821252 + (5.656453 * D) + (-0.103724 * D * D)$$

Sample Size = 31; R<sup>2</sup> = 0.792; Mean Square Error = 37.5656

$$Cubic\ Volume = -0.418741 + (-0.808604 * D) + (0.139637 * D * D)$$

Sample Size = 31; R<sup>2</sup> = 0.975; Mean Square Error = 14.7390

Exhibit 02 applies the regression equations to the stump cruise to arrive at the total estimated volume for the trespass.

## Chapter 20 - Measurements

Amendment: 2409.12b-2012-1

Effective date: August 16, 2012

## 20.2 - Exhibit 02

Stump Cruise with Estimated Volumes

Species	Stump Diameter (D)	Number Stumps	Estimated DBH <sup>1</sup>	Estimated Total Height <sup>2</sup>	Estimated Volume <sup>3</sup>	Estimated Total Volume <sup>4</sup>
LP	10	2	8.3	45.4	5.5	10.9
LP	11	6	9.1	48.8	7.6	45.5
LP	12	19	9.8	52.1	10.0	189.7
LP	13	30	10.5	55.2	12.7	380.0
LP	14	35	11.3	58.0	15.6	547.0
LP	15	24	12.0	60.7	18.9	452.9
LP	16	27	12.7	63.1	22.4	604.5
LP	17	29	13.5	65.4	26.2	759.5
LP	18	13	14.2	67.4	30.3	393.5
LP	19	19	14.9	69.2	34.6	657.9
LP	20	7	15.7	70.8	39.3	274.8
LP	21	5	16.4	72.2	44.2	220.9
LP	22	3	17.1	73.4	49.4	148.1
LP	23	1	17.9	74.4	54.9	54.9
LP	24	0	18.6	75.2	60.6	0.0
LP	25	2	19.3	75.8	66.6	133.3
LP	26	1	20.1	76.1	73.0	73.0
						4946.4

<sup>1</sup>DBH = 1.001498 + 0.733636\*D<sup>2</sup>Total Height = -0.821252 + (5.656453\*D) + (-0.103724\*D\*D)<sup>3</sup>Cubic Volume = -0.418741 + (-0.808604\*D) + (0.139637\*D\*D)<sup>4</sup>Estimated Total Volume = Number Stumps \* Estimated Volume

### **20.3 - Combined Scale and Comparison Cruise**

When some of the material remains on site and some material has been removed, a combination of scale and comparison cruise techniques can be used. It is important to keep the two populations separate when using this technique.

If the logs can be identified as belonging to a specific stump, scale the logs using the scaling procedures (sec. 21). Conduct a stump cruise on the remaining stumps and use comparison cruise data to determine the value of the removed material (sec. 20.2). Use the scaled information as the comparison cruise if there is an adequate sample size and range of stump diameters are the same. Otherwise, use standing trees from within the area or from an adjoining stand for a comparison cruise.

The scaled material represents felled material left on site while the results of the comparison cruise represent material removed from the site. The total of the two samples will represent the total volume of the theft or trespass material.

If logs have been moved to the extent where they can no longer be identified with a specific stump but still exist on site, scale the logs using the procedures defined in section 20.1, Log Scaling Procedures. Keep these logs separate from logs where the stump can be identified. This material represents downed material left on site already accounted for in the comparison cruise results. The comparison cruise results minus this scaled material represent the total volume of the material determined by the comparison cruise.

Exhibit 01 is a combined scale and comparison cruise example.

**20.3 - Exhibit 01**

**Scale and Comparison Cruise Example**

A trespass area containing 20 stumps has been identified. For three of the stumps, the felled tree can be identified. The logs for the remaining 17 stumps have been moved. Most of this material has been removed from the site except for 6 logs laying beside a road. The following steps should be taken:

1. Scale the material for the 3 stumps where the felled tree can be identified. Refer to section 20.1, Log Scaling Procedures for details.
2. Follow the procedure for the comparison cruise method (sec. 22) to estimate the volume associated with the remaining 17 stumps.
3. Scale the 6 logs using scaling practices described in FSH 2409.11 or FSH 2409.11a.
4. Keep each set of data separate.

**Total Trespassed Volume:**

The total trespassed volume is the sum of the 3 scaled downed trees plus the sum of the comparison cruise volumes. All other appraisal data for the trespass (DBH, Total Height, number of logs, and so forth) will be determined from the information collected on the 3 scaled downed trees and the results of the comparison cruise for the remaining 17 stumps.

**Total Volume of Material Left on Site:**

This is the sum of the volume for the 3 scaled downed trees plus the sum of the volume for the 6 scaled logs.

**Total Volume Removed From the Site:**

This is the sum of the volume estimated for the 17 remaining stumps using the comparison cruise data minus the sum of the volume from the 6 scaled logs.

## 20.4 - Local Volume Tables

An alternative to the comparison cruise method is to use local volume tables to estimate the stump volumes. A local volume table is a look up table designed to estimate volume based only on species and DBH. These types of volume tables tend to be very localized, related to a specific stand or area. All local volume tables need to be approved by the regional measurement specialist before they can be used on a trespass or theft case.

If the theft or trespass area is part of a timber sale and the material removed is similar in species and size to material cruised for the sale, develop a local volume table from the existing cruise data by using regression techniques to determine the relationship between volume and DBH. Refer to a mensuration text book for examples of regression equations and obtain help or mensurational advice if uncertain how to proceed. Maintain all regression output and reports.

Once the local volume tables have been developed and approved for use in the case, the relationship between stump diameter and DBH needs to be determined. Use regionally approved formulas or look up tables if they exist. If no approved formulas or tables exist, do the following:

1. Use the procedures for determining comparison cruise trees described in section 20.2 Comparison Cruise Method and select a sample of standing trees.
2. On each sample tree, measure DBH and stump diameter at the highest common stump height (sec. 20.2). All standing tree information needs to be collected by a certified cruiser.
3. Use regression techniques on this sample to determine the relationship between DBH and stump diameter.

Once the relationships between stump diameter and DBH have been developed, construct the local volume table for each species with a column for stump diameter, estimated DBH, and estimated volume. Be sure to document the stump height. Stumps can now be tallied by species and stump diameter. Determine the stump volume by applying the volume table to each estimated DBH for each stump. See section 20.4, exhibit 01 for an example of using volume tables.

Volume tables, by species or species groups, can also be created to estimate the volume of a tree based on DBH and total height or number of logs in the tree. These volume tables can be utilized in areas where the total height or number of logs can be determined by matching the top of a tree to a corresponding stump. The relationship between stump diameter and DBH will still need to be determined before these tables can be used. All volume tables need to be approved by the regional measurement specialist before they can be used on a timber theft or trespass case.



## Chapter 20 - Measurements

Amendment: 2409.12b-2012-1

Effective date: August 16, 2012

## 20.4 - Exhibit 01

Local Volume Table Example

The following local volume table equation was developed for white fir using cruise data from a timber sale where the trespass was committed.

$$\text{Vol} = 7.344152 - 6.834642 * \text{DBH} + (1.025912 * \text{DBH} * \text{DBH})$$

Sample Size = 32     $R^2 = 0.960$     Mean Squared Error = 1586.9580

A Regionally approved equation to predict DBH from stump diameter utilizes the equation:

$$\text{DBH} = -0.385491 + 0.880765 * \text{STUMPD}$$

Stump Diameter	Est. DBH <sup>1</sup>	Est. Cubic Volume <sup>2</sup>	Stumps Tallied	Total Cubic Volume <sup>3</sup>
10	8.4	22.6	8	180.4
11	9.3	32.5	23	748.6
12	10.2	44.1	48	2118.6
13	11.1	57.3	59	3381.7
14	11.9	72.1	73	5262.5
15	12.8	88.5	75	6633.9
16	13.7	106.4	76	8086.9
17	14.6	126.0	69	8690.8
18	15.5	147.1	70	10296.4
19	16.3	169.8	61	10359.1
20	17.2	194.1	63	12231.0
21	18.1	220.1	58	12763.3
22	19.0	247.6	65	16091.5
23	19.9	276.7	41	11343.0
24	20.8	307.3	32	9835.1
25	21.6	339.6	18	6113.3
26	22.5	373.5	19	7096.5
27	23.4	409.0	12	4907.6
28	24.3	446.0	3	1338.1
29	25.2	484.7	14	6785.3
30	26.0	524.9	5	2624.5
31	26.9	566.7	4	2266.9
32	27.8	610.2	6	3660.9
33	28.7	655.2	4	2620.7
34	29.6	701.8	1	701.8
35	30.4	750.0	5	3749.9
			912	159888.2

<sup>1</sup>DBH =  $-0.385491 + 0.880765 * \text{STUMPD}$

<sup>2</sup>Vol =  $7.344152 - 6.834642 * \text{DBH} + (1.025912 * \text{DBH} * \text{DBH})$

<sup>3</sup>Total Cubic Volume = Est. Cubic Volume \* Stumps Tallied