

**Forest Service Handbook
National Headquarters (WO)
Washington, DC**

**Forest Service Handbook 2409.12 – Timber Cruising Handbook
Chapter 40 - Cruise Planning, Data Recording, and Cruise Reporting**

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Responsible Staff:

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

41.1: Revises section to include stewardship contracts and to tie to exhibit 01, sampling errors.
Revises exhibit 01 to decrease sampling error on low value projects.

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41 - Cruise Planning

Prepare a cruise plan for each timber sale (FSM 2442.04c and 2442.2). At a minimum, the cruise plan must include:

1. A definition of the sample population(s).
2. The sampling method(s) and intensity for each population.
3. Product merchantability specifications for each population.
4. Sale area maps.
5. Silvicultural guides, when required.

41.1 - Sampling Error Standards

1. Apply sampling error standards for product quantity estimates on commercial timber sales and stewardship contracts which have a unit of measure and value based on tree stem volume or weight, and whose estimated sale value exceeds the threshold shown in exhibit 01.
2. When sampling errors apply, advertise only those sales that meet the standards. The maximum sampling errors are at the 95 percent confidence level (two standard errors or $t = 2$ in the appropriate statistical formulas for relatively large sample sizes). Apply sampling error standards at the sale level and the strata level.
3. For the purpose of design, estimate total sale value using the prices in effect when the fieldwork for the cruise is initiated.
4. Prior to initiation of fieldwork for the cruise, establish appraisal groupings for each market area.
5. Use the following error standards for the indicated stand components:
 - a. Sale-as-a-Whole Volume Error Standard. The error standard for the sale-as-a-whole is dependent on the estimated value of the sale; that is, the estimated value is the expected bid (ex. 01).
 - b. Stratum Volume Error Standard. The maximum sampling error for any one stratum is 50 percent for scaled sales, and 40 percent for tree measurement sales.

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Regional foresters may establish other standards, as appropriate, for specific salvage sale situations or for individual strata that represent 10 percent or less of the sale volume.

Check cruising is required for tree measurement sales in excess of 2,000 hundred cubic feet (CCF). Refer to section 61.3 for direction on the check cruising process.

41.1 - Exhibit 01

Maximum Sampling Errors for the Sale-as-a-Whole Volume Error Standard
(95 Percent Confidence Level)

Estimated Sale Value \$	Sampling Error %	
	Scaled	Tree Measurement
> 5,000 ≤ 10,000	± 35	± 25
> 10,000 ≤ 20,000	± 30	± 20
> 20,000 ≤ 45,000	± 30	± 18
> 45,000 ≤ 70,000	± 30	± 16
> 70,000 ≤ 95,000	± 30	± 14
> 95,000 ≤ 120,000	± 30	± 12
> 120,000	± 20	± 10

41.2 - Silvicultural Guides

Use the silvicultural prescription to determine the appropriate cutting methods. This prescription assists the cruise planner by identifying a stand treatment, which can include information about the species to be removed, and the leave basal area.

Consult with the responsible silviculturist to determine how to integrate the logging needs and conditions of the timber stand with the silvicultural prescription. Ensure that cruise instructions require all marking and cruising to be done within the prescription.

41.3 - Sampling Methods and Sampling Intensity

Use pre-cruise analysis as the first step in determining cruise methods and sampling intensity (ch. 30). This analysis may include data obtained from one or more of the following sources:

1. Reconnaissance Cruise. Use a reconnaissance cruise of the proposed sale area to provide reliable data for designing a cruise. Randomly locate enough sample units over the proposed sale area to support reliable estimates of coefficients of variation (CV) for the possible cruising methods.
2. Compartment Examination. Use compartment data to determine approximate volume, CV, and species composition. Ensure that proper comparisons are made; for example, the CV derived from point sampling is not reflective of the CV of individual trees.
3. Comparison Cruises. Use data from an adjacent area to estimate statistics for a proposed sale if the stands are similar in form class, tree spacing, and size variation. Comparison of non-similar stands could result in under-sampling, or over-sampling. If under-sampling occurs, a cruise would have to be redone.

41.31 - How To Use Pre-Cruise Data

To determine the most cost-effective cruise method(s), gather enough pre-cruise information to estimate the cost of each cruise method considered. Estimates may be based on the costs of the following:

1. Pre-cruise estimate of the coefficient of variation for the variable of interest of the population to be sampled for each cruise system.
2. Pre-cruise volume and area estimates by stratum.
3. Desired sampling error percent.
4. Stratification of cruises.
5. Number of sampling units required (such as plots, points, and trees) by stratum.

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6. Establishment (plots, points) and measurement of sampling unit(s) (plots, points, and trees).
7. Acreage determination.
8. Tree marking (including paint) or other form of designation.
9. Data recording.

Use the calculations to compare the costs of different cruising methods to arrive at the method of least cost for the sale-as-a-whole and for each of the sampling strata within the sale.

41.32 - Supplemental Samples

1. In most sampling situations, design the cruise to sample all the identified species or populations in the sale.
2. In rare instances, a minor species or population, for which no sample is selected, may be recorded in the tally. Without a sample, an expanded volume for the species or population cannot be calculated. To avoid such a situation, either combine the minor species or population with a larger species group or population or, if that approach is not feasible, make a sample tree of the first tree encountered of a minor species or population (this approach introduces a bias in the sampling but ensures that the minor species or populations are included in the sale, if no other valid samples are taken).
3. When the original cruise exceeds the desired sampling error and a small number of additional samples are needed to reduce the error to an acceptable level, calculate the total number of additional samples needed, locate and measure unbiased samples in the field, and add these data to the original cruise. Use this method one time only. If the error remains unacceptable, redesign and redo the entire cruise.

41.4 - Stratification of Cruises

1. Assess the potential benefits of stratification for reducing the overall sampling cost during the cruise design process. Proper stratification of samples improves the estimate; requires a smaller number of samples to meet the accuracy standard; and provides a confidence estimate for the different components of a sale, such as for high and low-value species. The following are some examples of cruise stratification methods that can be used. Other examples are provided in sections 41.41 through 41.46. Regional foresters may supplement the direction in these sections with examples of stratification methods typical for the region (sec. 04).
 - a. For area-based sampling, group the units by stands, timber types, site quality, or other characteristics that reflect a degree of similarity in the volume or value to be cut per acre.

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- b. For tree-based sampling, group the populations by tree species, size, or value.
2. Stratify heterogeneous populations to provide more precise estimates of total sale volume or value for a given sample size. Maximize the differences between groupings; minimize the differences within groupings; and ensure that each group has an adequate number of samples for the population estimates to be useful.
3. Do not stratify homogeneous populations, very small jobs, or uniform cuts because this form of stratification does not improve precision and can have a negative effect on the confidence limit.
4. Do not over stratify. Too much stratification causes the need for increased levels of sampling to meet the accuracy standard.
5. Do not post stratify. Stratification after the field samples are taken does not permit optimum allocation of samples by strata and introduces bias in the estimate.

41.41 - Timber Type

Consider the use of timber type as the basic stratification identifier when both of the following criteria apply:

1. More than one timber type exists in the cutting area, and
2. The largest differences in volume and value between timber types can be explained by the characteristic differences between the timber types.

41.42 - Stand

Consider the use of stands as the basic stratification identifier when both of the following criteria apply:

1. More than one stand exists in the cutting area, and
2. Significant differences in volume and value exist between the stands.

41.43 - Payment or Cutting Unit

Consider the use of units or groups of units with similar treatments as the basic stratification identifier when all of the following criteria apply:

1. The timber sale is comprised of more than one cutting or payment unit,
2. Significant differences in volume, value, or variable of interest exist between the units or groups, and

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3. Different marking intensities or sampling methods are used in the individual units or groups of units.

41.44 - Species

Consider the use of species as the basic stratification identifier when both of the following criteria apply:

1. More than one species will be cut, and
2. Significant differences in volume, value, defect characteristics, or other variables of interest exist between the species.

41.45 - Diameter

Consider the use of the diameter at breast height (DBH) class as the basic stratification identifier when all of the following criteria apply:

1. A large variation in diameters exists,
2. A sample tree with complete tally (sec. 33) or 3P-sampling (sec. 36) will be used, and
3. The DBH class accounts for the major differences in volume, value, and defect characteristics.

When using the DBH class to identify a population, do not change the estimated class of the tree if the DBH measurement is different from the estimate, or the measurement of sample trees represents other trees in the class that are incorrectly estimated.

41.46 - Other Stratification Methods

Use any other method of stratification that improves the efficiency and accuracy of timber cruises more than the commonly used methods.

41.5 - Merchantability Specifications

1. In the cruise plan, specify the:
 - a. Minimum tree size,
 - b. Product specification,
 - c. Tree diameter,
 - d. Number of product units,
 - e. Product length,

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- f. Diameter inside bark at the small end, and
 - g. Net scale as a percentage of gross.
2. Use the specifications in effect for the area when completing the cruise plan.
 3. Specify the utilization standards and timber designation requirements that have to be met in order to complete the cruise plan (FSH 2409.15).
 4. When pulpwood and substandard materials are to be cruised as part of the proposed sale, list the instructions for measurement and recording of the material in the cruise plan. Use the Region's merchantability requirements for cruising pulp logs and substandard material.
 5. Include special instructions, such as counting or linear measurements, for cruising special products like railroad ties, firewood, poles, posts, piling, shake bolts, and mine timbers. Length and strength are often more important for such material than the volume they contain. The cruise design must account for length, diameter limits, and allowable defect for the products specified in the cruise.

41.6 - Sale Work Maps

1. Include the work maps and photographs necessary to execute the cruise. The maps of each cutting unit or other subdivision must contain locations of lines, plots, or strips.
2. Use cutting unit cards or similar documentation to summarize and record field information and instructions from the interdisciplinary team that completed the environmental analysis and the responsible official (line officer) who made the National Environmental Policy Act decision.

41.7 - Special Instructions

Include the following special instructions, as appropriate.

1. Cruising Under Hazardous Conditions. When the pre-cruise survey shows that abnormal cruising conditions are present, the cruise plan should provide the appropriate safety instructions, such as:
 - a. Stay away from snag areas and broken, wind-damaged tree stands during windy or heavy snow-load periods.
 - b. Wear non-slip footwear while cruising heavy concentrations of blown-down timber.
 - c. Maintain radio contact when cruising in isolated and remote areas.

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2. Timber Product Volume Estimators. The cruise plan may specify the volume estimation tables to be used on the cruise. Section 22 explains the functions of timber product volume estimators.
3. Painting Requirements. The cruise plan must include security requirements for the use of tracer paint or any special paint marker that may be used. See chapter 70 for direction on tree marking.
4. Cruising Stands With Catastrophic Damage. The regional forester shall provide instructions necessary to cruise stands that contain windthrown and broken trees from major windstorms, fire damage, insect epidemics, and flood damage.

41.8 - Quality and Value Determination

List in the cruise plan the tree and log grading guides to be used when cruising for quality and value on the proposed timber sale, especially in areas with higher-value softwood and hardwood sawtimber.

41.9 - Safety in Cruising

Hazards in cruising require all members of the crew to be safety minded at all times. Each crew leader shall have access to a copy of FSH 6709.11, Health and Safety Code Handbook, and shall provide training and information on safety practices for the cruising crew before and during cruising assignments.

Following are cross-references to subjects in FSH 6709.11, Health and Safety Code Handbook that pertain to individuals engaged in cruising projects:

Chapters	Subjects
Chapter 10 - Travel Chapter 20 - Work Projects and Activities	<ul style="list-style-type: none">• Travel safety for the cruising assignment• Work in remote areas• Scaling while on training assignment• Scaling on mill decks• Scaling in mill yards• Timber sale administration, while training or working near logging operations• Tree felling and bucking
Chapter 40 - Equipment and Machinery	<ul style="list-style-type: none">• Chopping tools and cutting tools

42 - Data Recording

42.1 - Standard Codes

Use the codes in FSH 2409.14, chapter 80, for recording cruise data. The regional forester shall establish the codes for cruise items not listed in the referenced handbook.

42.2 - Tree Tally Techniques

Use the dot-and-dash notation (☒), which counts in units of ten, as the standard manual tally method for processing and summarizing the cruise data.

42.3 - Field Aids and Recording Equipment

42.31 - Field Aids

Use the following field aids to promote accuracy in data recording:

1. Species codes.
2. Tree codes.
3. Location codes.
4. Tree and log grading rules.
5. Percentage deduction tables.
6. Standard upper limit diameter outside bark (DOB) by species.
7. Limiting distance tables for point sampling.
8. Stratification guides.

42.32 - Recording Equipment

1. Cruisers must be equipped with an electronic data recorder or a clipboard with a receptacle for storing cards.
2. Pencils with firm (F) grade lead should be used, but hard black (HB) lead is also acceptable. Other grades are unacceptable. Grades 2H, 3H, or soft grades are difficult to erase cleanly; very hard leads produce especially poor results if the recording paper is damp.
3. Other equipment that may be used includes:
 - a. Compass.

- b. Diameter tape.
- c. 100-foot metal or cloth measuring tape.
- d. Packsack or vest.
- e. Ribbon and tree marking paint.
- f. Angle gauge.
- g. Height measuring instrument.
- h. Pacing stick.
- i. Marking pens.
- j. Tally sheets.
- k. Random sample selection device.

42.4 - Forms and Electronic Data Recorders

42.41 - Forms

Use the approved formats for recording cruise data in a consistent manner. Avoid recording data on notebook sheets or other non-standard sheets for subsequent transcribing to standard tally forms. Subsequent transcribing is inefficient and may result in lost records or transcription errors.

Regions shall maintain consistent and approved formats for recording cruise data (FSM 2442.04). Avoid the use of local forms. Provide standard waterproof forms where cruising must be done under damp conditions. Forms should be printed in green ink on a white background for ease of reading.

42.42 - Electronic Data Recorders

Use electronic data recorders whenever possible. Regions must provide standard programs for data entry; local programs are not permitted.

42.5 - Other Recording Requirements

Cruisers must write numerals and letters legibly avoiding ambiguity to ensure that the data entry operator can accurately enter cruise data into a computer from source documents. Allow ample space for data recording to enable instant, correct recognition by the data entry operator. Edit the data before leaving the plot or point and edit immediately after recording the data for a single tree in sample tree cruises.

42.6 - Data Security

Because timber sale valuation is based on cruise data, it is necessary that cruisers protect any collected data from inadvertent, or willful and fraudulent changes. Use any password or audit trail features available in the data collection software. Secure all completed data collection forms or data recorders in a locked environment to ensure access only by authorized personnel. Scan any paper forms and electronic data for indications of possible unauthorized changes.

43 - Cruise Reporting

43.1 - Information to Report

Compute the necessary information for the particular type of timber sale appraisal, prospectus, contract, and payment method. As needed, generate information such as estimates of live-cut volume and numbers of trees by species; cut volume sampling statistics; dead timber volume and trees; timber quality tabulations; unsound sapwood data; and various appraisal tables.

43.2 - Volume, Value, and Sampling Error Reporting

1. Cruisers may use either the National Cruise Program (NATCRS) or the regional computer programs established by the regional forester for calculating and reporting the results of timber cruises. Follow the procedures in chapter 30 to calculate timber cruise estimates.

Computer programs must accommodate data from all regional cruising systems. Outputs must satisfy informational needs for preparing the appraisal, prospectus, and contract.

- a. Document the computer software systems used to process cruise data.
 - b. At a minimum, include descriptions of all expansion procedures and statistical calculations for all sampling methods supported. Documentation for the National Cruise Program is available electronically on the FS Web/Internet by accessing the Forest and Rangelands Staff website at: <http://www.fs.fed.us/fmsc/measure/cruising/>.
 - c. Provide the required volume and value estimates for developing the appraisal, prospectus, contract, and sum for the sale as a whole.
 - d. Show the sampling error by timber sale component and for the sale as a whole.
2. Regions may supplement this section with descriptions of, and user instructions for, the selected timber cruise programs.

43.3 - Area Information

Acreage measurements, by total sale and by any subdivision, should be as accurate as possible. The magnitude of the volume error is in direct proportion to the area error for area-based cruises.

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For example, if the acreage measurement error in area is 10 percent high, the volume estimate is also 10 percent high. Summarize point-sample and plot-sample data on a per acre basis, and expand the data by the number of acres in the tract.

Where a closed traverse is used, state the error of closure. See chapter 50 for detailed direction on area determination. Include a statement of the method used to determine area in the timber sale file.

43.4 - Other Information

The cruise report may also include the following elements by payment or logging units:

1. Logging method.
2. Percent slope.
3. Method of cut.
4. Sawtimber weights by DBH (diameter at breast height) classes.
5. Chippable component weights (outside of sawlog portion of stem).
6. Sell-product volumes in terms of local log rules.
7. Sell-product volumes in cubic feet for each product.
8. Cut-basal area per acre.
9. Color of marking paint.
10. Environmentally important items not previously identified.

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43.5 - Certifying Cruise Information

Include a copy of the cruise inspection summary sec. 63 in the timber sale file, and provide a cruise certification signed by the District Ranger. The cruise inspection summary must show the names of cruisers and other workers, date of certification, and date of last check. See exhibit 01 for an example of a cruise certification. This certification is required in addition to the certification required when Gate 3 is completed (FSH 2409.18, sec. 12).

43.5 - Exhibit 01

Certification of Cruising Standards

CRUISE CERTIFICATION

I certify that the timber for the Dry Creek timber sale has been designated and cruised by the procedures and standards in FSH 2409.12, Timber Cruising Handbook. Records of checks are on file at the Big Pine Ranger District, Dry Lake, California .

/s/ John H. Smith
District Ranger

8/20/2002
Date

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43.6 - Disposition of Records

Dispose of records in accordance with direction in FSH 6209.11, Records Management Handbook.