## Timber Cruising in the Pacific Northwest

## Basic Cruiser Training Workbook



United States Department of Agriculture
Forest Service
Pacific Northwest Region

## Region 6

Forest Service

## U.S. Department of Agriculture

## Timber Cruising

in the

## Pacific Northwest

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## Objectives

## Learn, Apply, \& Practice

1. Cruise process and procedures.
2. Terminology associated with cruising.
3. Data collection and documentation
4. Proper techniques for taking tree measurements.
5. Characteristics used to identify tree species.
6. Evaluate sawlog, non-sawlog and cull products.
7. Identify tree defects and make defect deductions.
8. Region 6 common sampling methods.
9. Written test.

## Preface

This workbook provides instruction on the basic cruise measurements, as well as five primary cruising methods currently used in Region 6. It's designed to supplement instructor lecture and field application. This course stresses correct individual tree measurements, and a working knowledge of $\mathbf{1 0 0 \%}$, Sample Tree, 3P, Fixed Plot, and Point Sample cruise methods. This workbook will be used to develop consistency for timber cruising across Region 6.

There are four levels of certification for cruisers.

Qualified Cruiser: The qualified cruiser is responsible for applying a variety of volume determination techniques. As a minimum, the cruiser must be proficient in cruising fundamentals such a tree measurement, species identification, defect recognition and determination, quality determination, map reading and compass use traversing, photo interpretation, working knowledge of the commonly used cruise systems and be able to interpret and follow a timber cruise plan.

Advanced Cruiser: The advanced cruiser is fully qualified to design, perform measurements, train prospective production cruisers, conduct all types of timber cruises, and design and implement cruises. Experience, technical interest, training ability, and initiative characterize this classification.

Check Cruiser: The check cruiser is responsible for check cruising, cruiser training and conducting evaluations to recommend certification of qualified and advanced cruisers. The check cruiser maintains an active field check cruising program, retain records of individual cruisers, retains records of sale check cruise results. The check cruiser inspect timber cruises and recommend acceptance or identify deficiencies and corrective actions for them. Additionally, they are responsible for establishing Forest certification test areas.

Master Cruiser: The master cruiser is certified by the Regional Forester and serves as a representative for cruising and coordinates the Regional quality control program.

## Introduction

Timber cruising is the process of tree selection and measurement that determines the volume and value of usable wood in standing trees.

Region 6 has approved two log rules for determining volumes; Scribner Decimal C Log Rule and the Smalian Cubic Foot Log Rule. The National Cruise Program calculates volume in board feet for Scribner Decimal C Log Rule and in cubic feet for the Smalian Cubic Foot Log Rule.

National Forests in Washington and Oregon sell timber to private corporations and individuals. In order to receive a fair value for the timber, cruisers must collect accurate information.

National Forests have plans that furnish direction on how lands will be managed to provide opportunities for recreation, timber harvest, grazing, and a wide variety of other uses. The goals set in these plans determine how much, where, and when timber may be removed.

Ranger Districts further refine plans that schedule timber harvest over a period of several years. These plans estimate the volume of wood that will be removed and are valuable to private industry for planning future mill operations.

Before the proposed harvest, Categorical Exclusions (CE), detailed Environmental Analysis (EA) or Environmental Impact Statement (EIS) are prepared. People within and from outside the Forest Service work together during the analysis and timber sale planning process and the results of these documents discloses effects the planned sale will have on the environment, and establishes objectives for longrange management.

Silviculturists work closely with other specialists and write prescriptions and tree marking guides that achieve these objectives.

Sale Preparation Teams lay out units and designate trees to be cut. Timber cruisers, as part of the team, determine the Volume and Value of wood to be removed, and in many cases, act as both marker and cruiser.

Region 6 sells two types of sales: Tree Measurement Sales (TMS) and Scaled. TMS are sales in which the volume is determined by cruising and is paid for prior to removing the trees. Scaled sales are sales in which the volume offered for sale is determined by cruising but payment is made after trees are removed, hauled to the mill and scaled for actual volume.

All timber sales, land exchanges, and trespass cruises shall be cruised by certified cruisers.
Data collected by cruisers, such as average tree size and volume per acre, is used in the Timber Sale Appraisal, which determines the price of the timber offered for sale. Errors in data collection will affect volume estimates, which affect the payment received by the government from timber sales, either scaled or tree measurement sales.

Demand for timber resources within our National Forests has created the potential for conflicts.
Accurate timber volume estimates can reduce potential conflict and are important in monitoring Forest Plans, insuring adequate log accountability, and receiving full value for what is sold.

## Cruise Planning

Prepare a cruise plan for each timber sale (FSM 2442.04c, 2442.2 and FSH 2409.12). At a minimum, the cruise plan must cover:

1. Sampling Methods(s).
2. Sampling intensity.
3. Product merchantability specifications.
4. Sale area maps.
5. Silviculture guides, when required.

The cruise plan provides instruction for the cruising crew. It will cover all pertinent cruising elements for the timber sale involved. Consider the checklist below when preparing a cruise plan:

1. Silviculture prescriptions and/or marking guides.
2. Sampling, or cruise design, include cruise method(s) and intensity (ies) by unit and the analysis leading to the design. In cruise design, consider size and shape of units, payment units, right-ofway, landing clearings, riparian zones, wildlife trees, and so forth. List sample groups, units and strata.
3. Sale or cruise number.
4. List Unit of Measure: Cubic or Scribner
5. Product merchantability specifications (may tie into species and relative values).
6. Sale area working maps, including sample plot location maps.
7. Safety items specific to the sale.
8. Special measurement techniques: for example, how to handle visible and hidden defect and breakage, Mirage Points (points close to boundaries), and rounding rules, i.e., carry all mathematical calculations a minimum of five (5) characters to right of decimal point before final rounding. When final rounding, use one character to the right of the desired accuracy. When rounding to two decimal places evaluate the third, i.e., round .36542 to .37 or round .36442 to . 36 .
9. Will stem profile equations be used, if so, which ones?
10. Will form class need to be determined? Using what method?
11. In an area-based cruise, describe how the unit acreages will be determined, traversed, or GPS'd, and how the stations will be monumented.
12. Describe how sample points and sample trees will be marked and monumented (ribbon color, plot stakes, paint color).
13. What will be the plot location controls - how will distances between plots be measured? Will cruise lines be referenced to unit boundary traverse stations or a base line? How to locate the first point in a unit? How will the location of STR/3P sample trees be documented - map, photo?
14. Log grading (product designation): Grade $1=$ Sawlog Grade 8 = Non-Sawlog Grade $9=$ Cull.
15. How are cut and leave trees marked? See Forest Accountability Action Plan
16. How will tree heights be measured and recorded - Total Height, Merchantable Height in Feet or Log Height? How to differentiate these three on cruise cards. What is the top DIB to cruise to by species?
17. Special/local defect (instructions) guidelines, i.e., worm holes, char, etc.
18. If a 3P cruise is planned, how will KPI's be estimated - gross or net? What aids will be given to the cruisers to help estimate KPI's?
19. If a Sample Tree cruise is planned, how will sample trees be selected? Will a random number list be provided - by species?
20. What Subpopulation codes will be used?

## Data Recording

An integral part of good sampling and cruising techniques is accurate and legible data recording.
Mistakes made at this point are often difficult to detect and correct in the office. All header information must be filled in completely!

There are two types of data recording: card entry and electronic handheld data recorders.
Region 6 uses two types of cards to record cruise data in the field.

1. R6 FScruiser TREE CARD (R6-FS-2400-405)
2. R6 FScruiser 3P TREE CARD (R6-FS-2400-404)

R6 FScruiser TREE CARDS are used for all cruises except 3P.


## Heading

Forest and District are entered as two digit codes.
Cruiser name shall be filled out in full, not by using initials. Only certified cruisers shall be listed.

Date is the day(s) the cruise data was collected.
Sale Number shall be filled out.
Sale Name is to be completed in full.
Strata Number will come from the cruise plan.
Unit Number must be filled in for all sampling methods.
Point/Plot Number is required for area based cruises. Enter only one point/plot per card.
Sighting Point refers to the location on the tree where the determination of In or Out trees is made. This is always DBH. (This is not applicable on cruise cards dated $11 / 05$ or newer.)

BAF (Basal Area Factor) is filled in when point sampling.

## Tree Information

Tree \# shall be entered on measured points/plots and individual trees.
CNT/MEAS is a one-position entry. $\mathbf{C}$ for count and $\mathbf{M}$ for measure.
SG is alphanumeric and is required in most cases. Blank (no entry) is a valid code. Only two characters allowed. (This is applicable on cruise cards dated 11/05 or newer.)

Specie Code is alphanumeric and is required. Can have up to four characters.
SLUPCY (Et AI) Code should be used to enter sample group. Only two characters allowed. (This is not applicable on cruise cards dated 11/05 or newer. Has been replaced with SG.)

DBH is required and is entered in tenths of an inch.
Tree Count is required on PCM (POINT, COUNT, MEASURE), FCM (FIXED, COUNT,
MEASURE) and P3P (POINT 3P). On measure points, enter 1 for each tree. On count points, enter total count of trees by Sample Group and Species code as listed in the Subpopulation Table.

Stem Profile Equations require total height or merchantable height in feet. Cruises using $\mathbf{6 1 6}$ Equations require total height or log height.

Total Height is entered to the nearest foot.
Merchantable Height in Feet is entered to the nearest foot.
$\mathbf{L o g}$ Height is entered to the nearest half $\log$ and will end in 0 or 5 ; minimum is one $\log (010)$. Example: 4 and $1 / 2$ logs is entered as 045 .

Top DIB is optional when cruising to a total height. If left blank, the contract minimum specified in the cruise plan will be used. Top DIB is required when cruising to merchantable height in feet and log height.

Defect Percent is applied to the entire tree. Defect in this field and in log defect fields are cumulative. This entry is not commonly used. (This is not applicable on cruise cards dated 11/05 or newer.)

Form Class is optional. If left blank, the Form Class listed in the cruise plan will be used.
Log Grade Position: The top row is used to enter the grade (product designation) of each log by position. Logs are graded in maximum 16-foot segments.

Defect deductions are also made by log position. Deductions must be made on visible indicators and are entered as a $\%$ of $\log$ volume to be deducted. Logs are defected in maximum 16 -foot segments.

## Merchantability Specifications

Product
Sawlog (Grade 1)
Non-sawlog (Grade 8)
Cull logs (Grade 9)

Maximum Defect
$\frac{\text { Cubic }}{60 \%} \quad \frac{\text { Scribner }}{66 \%}$
Cruise for gross volume only, no defect deductions.
N/A when Non-sawlog products are included in the cruise.

R6 FScruiser 3P Tree Cards are used exclusively for 3P cruises.
Tree Number is assigned to each cruise tree.
KPI (volume estimate) is the cruiser's estimated volume.
3P Code: 1 is for 3P Sample; 2 if for Fall, Buck, and Scale, 3 is for Sure to Measure.

## R6 FScruiser 3P TREE CARD



## Editing

Editing is an important part of data collection. No matter how accurately the measurements were taken, if data was recorded incorrectly or omitted, then, at the very least, you have biased the cruise.

A first field edit should be done before leaving the point/plot or cruise tree to insure all necessary data has been recorded. A second field edit should be done at the end of the day to assure you did not loose any field cards.

An office edit of the field cards must be made by an experienced cruiser prior to data entry and then after data entry to check for input errors. This is especially true if the data entry is done by someone with no knowledge of cruising.

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## Module I - Tree Measurement

The foundation for all consistent cruise results is accurate measurements. Sloppy measurements will not balance out. There is almost always bias, one-way or another, when taking poor measurements.

Bias is a systematic error. Measurement bias occurs when an instrument is out of adjustment and inaccurately measures each sample by a fixed amount. Estimation bias occurs when a volume estimator consistently over or under estimates actual tree volumes. Selection bias occurs when selected plots over or under represent a timber condition.

## Methods of Measurement

Region 6 uses two units of measurement: Cubic and Scribner.
Cubic volume is determined using the Smalian Cubic Formula.
The Smalian Cubic Formula calculates volume in units known as cubic feet. The dimensions of a cubic foot are 12 inches by 12 inches by 12 inches.

Volumes are calculated using the length of the log, the small end diameter and the large end diameter. Volumes are calculated for each log segment.


Cubic Foot


The Cruise Processing program computes volume for each log segment, adds those together, giving the total volume of the tree.


## Methods of Measurement Continued

Scribner volume is determined using the Scribner Decimal C Log Rule.
The Scribner Decimal C Log Rule calculates volume in units known as board feet. The dimensions of a board foot are 1 inch by 12 inches by 12 inches.

Volumes are derived from a table showing an estimate of the amount of lumber a $\log$ of a given length and diameter can produce. This table uses the small end diameter and a scaling cylinder, which is an imaginary cylinder extending through the log length with a diameter equal to the small end.

Volumes are calculated for each segment.


Board Foot


The Cruise Processing program computes volume for each log segment, adds those together, giving the total volume of the tree.


## Volume Determinations

Two types of volume equations are currently used: 616 (Behr's Hyperbole) and Stem Profile (Ingy and Flewelling). Both of these equations can be used to determine cubic and scribner volumes.

Three measurements are required to calculate volume when using 616 equations: DBH, Height and Form Class.

Only two measurements are required to calculate volume when using Stem Profile Equations: DBH and Height.

DBH and height measurements are the same regardless of the unit of measure or what cruise method is used.

With these measurements, the cruise program can determine number of logs, log lengths, log end diameters and calculate tree volumes.

## Cruising Instruments

Commonly used equipment for timber cruising is:

Spiegel Relaskop
Clinometer
Prisms
Compass
Diameter Tape
Loggers Tape
Laser Scopes
Tatum Aids

Data Recorders
Cruise Cards
Measuring Tapes/Devices
Hatchet/Axe
Binoculars
Calculators
Aerial Photo Scales
Telescoping Poles

Safety items to consider while cruising are:

1. Radio
2. Hard hat
3. 8 " high, non-skid soled boots
4. Long sleeve shirts
5. $1^{\text {st }}$ Aid/bee sting kits
6. Safety glasses
7. Gloves
8. High visibility vest
9. Review JHA

## Diameter

Diameters are normally taken at $\mathbf{4 . 5}$ feet above the natural forest floor, on the high side of the tree. This point is known as Diameter at Breast Height or DBH.

Diameter tapes must be perpendicular to the tree bole. Some conditions causing incorrect DBH measurements include: twisted tapes, sag in tapes, measuring abnormalities at DBH or reading the tape upside down.


Occasionally debris will obstruct the base of the tree. DBH measurements are taken from the normal natural forest floor or duff layer. Disregard piled debris such as dirt, rocks, limbs or logs.


## Diameter tapes convert circumference to diameter measurements.

Numbers on the tape should be read right side up to avoid reading errors.


Diameters are rounded down to the nearest $\mathbf{1 / 1 0}{ }^{\text {th }}$ inch.


12


12
13


Right hand and left hand tapes are available.


Left Handed (counter clockwise)


Right Handed (clockwise)

Leaning Tree DBH is measured perpendicular to the tree bole (right angle).


Tree with Forks Above DBH are measured as One tree.


Trees with Forks Below DBH are measured as Two trees.


Trees grown together are measured as two trees. This is indicated by a bark seem above and below DBH.


Measure as close as possible to the DBH and adjust for each tree.
Cankers or burls located at DBH can be measured using two methods.

## Method A: Measure as close as possible to DBH and adjust for taper.



Severe catface and abnormal butt swell are measured above the swell while noting the height of that measurement.

Estimate the average taper in normal trees of comparable size, and apply taper rate to approximate DBH.


Catface or scar will be measured by extending the tape.


Trees growing on objects (rocks, logs) are measured from the root crown.


Split or shattered trees are measured as close to DBH as possible then adjusted for taper.


## Abnormal Diameters

Class Problems

No. 1
Instructions: Draw location of measure point(s).
Make notes to help describe measurements.
a.)
b.)
c.)
d.)
e.)
f.)
g.)

e


## Heights

Three types of height measurements can be taken: Total Tree Height, which is recommended, Merchantable Height in Feet and Log Height.

1. Total Tree Height--- measurements are taken from stump height to the tip of the leader and recorded in feet.
2. Merchantable Height in Feet---measurements are taken from stump height to a specified top or contract minimum diameter and recorded in feet.
3. Log Height---measurements are taken from stump height to a specified top or contract minimum diameter and recorded to the nearest one-half log.

Cruises using a Stem Profile Equation must use either Total Tree Height or Merchantable Height in Feet and cruises using a 616 Volume Equation must use either Total Tree Height or Log Height.

Stump height is 12 " on the high side from the natural forest floor.


## Total Tree Height

When Total Height cruising, a minimum Top Diameter Inside Bark (TOP DIB) is not required and should be assigned as an override in the cruise plan. This is usually the minimum contract diameter. Volume is calculated to the Top DIB.

Total tree height is measured from the stump to the tip of the leader and recorded to the nearest foot.

Example 1: Standing trees


Example 2: Broken off trees - measure standing portion to the break, then measure portion on the ground from the break to the top of the tree and add together for total tree height.


## Merchantable Height in Feet <br> (Specified Top)

Tree height is measured from stump height to a Specified Top Diameter or Contract Minimum Diameter and recorded in feet.

Top Diameter Inside Bark (Top DIB) must be recorded. This is the point on the bole where no more merchantable products are expected.

Several factors influence the placement of this Top DIB.

1. Minimum Contract Diameters. (Example 1)
2. Specified Top. (Example 2)

Example 1: Minimum Contract Diameter


## Example 2: Specified Top

a. Broken top trees: Measure to the break and record height in feet and specified top DIB at this point. Disregard the break if it occurs above the minimum contract diameter.

b. Flat topped trees: Measure to the point where diameter is too small or too defective (where no more merchantable products are expected) and recorded in feet.


## Log Height

Procedures for measuring Log Heights are the same as for Merchantable Height in Feet only feet are converted to logs. Heights are measured from stump height to a specified top or contract minimum top diameter and recorded to the nearest one-half $\log$. Log lengths are 16 feet (full) and 8 feet (half). Minimum length is one $\log (010)$.

The table below uses the Range method for determining Log Height. Measured height is assigned a corresponding number of logs. Actual heights include trim allowance of .5 foot per log.

This table is used for determining log heights.


## Forked Trees

Forked top trees are measured by two methods depending on the fork location.

Trees forked below DBH are measured as two trees.

Two Trees


Trees forked above DBH are measured as one tree.


Snag top or dead top trees are measured the same as live trees with appropriate defect taken for unmerchantable wood.

## Relaskop Use

The Spiegel Relaskop is the primary measurement instrument in Region 6. This instrument may be used to obtain height and diameter measurements. It may also be used in measuring basal area and for determining slope corrections. The Relaskop automatically adjusts for slope and the internal bar width varies to compensate for slope. When measuring heights, the Relaskop does not adjust for slope distance.

Relaskops have Percent (\%), Topographic (T), and Degree ( ${ }^{0}$ ) scales.
Relaskops can be read directly at $100^{\prime}($ Percent - \%) and 66' (Topographic - T).
If heights are taken from other than these two horizontal distances, readings will require adjustments. To do this, multiply your height reading by the height reading factor listed below.

- Measure out at least as far as the tree is tall.

| Percent Scale (\%) |  |
| :---: | :---: |
| Horizontal Distance | Height Reading Factor |
| $83^{\prime}$ | 0.83 |
| $100^{\prime}$ | Read Direct (1.0) |
| $125^{\prime}$ | 1.25 |
| $200^{\prime}$ | 2 |
|  |  |


| Topographic Scale (T) |  |
| :---: | :---: |
| Horizontal Distance | Height Reading Factor |
| $33^{\prime}$ | 0.5 |
| $66^{\prime}$ | Read Direct (1.0) |
| $99^{\prime}$ | 1.5 |
| $132^{\prime}$ | 2 |



The following example illustrates how to establish a known horizontal distance on slopes. A correction must be made for any measured distance on slopes greater than $5 \%$.

Slope $=48 \%$
Slope Adjustment Factor = 1.11


Procedure:

1. Measure out the appropriate desired distance (A-B).
2. Measure the slope using the Percent Scale (\%). (Parallel to ground; eye height to eye height.)
3. Locate the corresponding slope adjustment factor from the chart in the Tatum Aid or Training Workbook.
4. Multiply the desired distance (66 feet in this case) by the slope adjustment factor (1.11).
$66^{\prime} * 1.11=73.3^{\prime}(\mathrm{A}-\mathrm{C})$
$73.3^{\prime}$ (slope distance) on $48 \%$ slope equals 66 ' horizontal distance, so you need to tape out an additional 7.3'.

When measuring height, the distance below and above horizontal needs to be accounted for.
It's most preferred to read a negative (-) number when sighting at stump height. This negative number is added to the positive reading ( + ) at the top of the tree to get the height from stump to top.

Sighting uphill at stump height will give positive (+) readings. This positive number is subtracted from the positive reading at the top of the tree to get the height from stump to top.

- Measure height from uphill or side hill whenever possible.

Example 1: Stump height below sighting point (negative number).

$$
\begin{aligned}
& \mathrm{A}=+65^{\prime} \\
& \mathrm{B}=-57^{\prime} \\
& \mathrm{A}-\mathrm{B}=122^{\prime} \\
& 65^{\prime}-\left(-57^{\prime}\right)=122^{\prime}
\end{aligned}
$$



Example 2: Stump height above sighting point (positive reading).

$$
\begin{aligned}
& \mathrm{A}=+127^{\prime} \\
& \mathrm{B}=+8^{\prime} \\
& \mathrm{A}-\mathrm{B}=119^{\prime} \\
& 127^{\prime}-(+8)=119^{\prime}
\end{aligned}
$$



## Leaning Trees

Leaning trees should be measured at right angles to the lean. Trees that lean towards the cruiser will have a larger critical angle, thus resulting in a taller height measurement. Conversely, trees leaning away from the cruiser will have a smaller critical angle, resulting in a shorter height measurement.

Trees leaning $25 \%$ (about $\mathbf{1 5}^{\circ}$ ) or more from vertical need a height adjustment.
Procedure: a. Measure vertical distance. (A to B)
b. Measure horizontal distance. (B to C)
c. Calculate correct height. (A to C)

$A \operatorname{TOB}(A B)=100^{\prime}$
$\mathrm{AC}=\sqrt{A B^{2}+B C^{2}}$
В TO C $(B C)=42^{\prime}$
$A \operatorname{TO} C(A C)=? ? ?$
$\mathrm{AC}=\sqrt{10,000^{\prime}+1,764^{\prime}}$
$A C=108^{\prime}$

## Height Measurements

1. Region 6 currently utilizes three tree height measurement types. What are they? Describe briefly.
a.
b.
c.
2. What are the heights of the leaning trees?
a.
b.


## Diameter Instruments

Relaskops and diameter tapes are used to take diameter measurements.
Diameters can be measured using various bar width combinations with the Relaskop. Diameters must be read at known horizontal distances.

Bar widths used for measuring diameters vary as the Relaskop is tipped up and down; only in this regard does it adjust for slope. When measuring heights, the Relaskop does not adjust for slope distance.


| Bar Width Equivalents |  |  |
| :---: | :---: | :---: |
| Horizontal Distance | Small Bars | Pair of Large Bars |
| $33^{\prime}$ | $2^{\prime \prime}$ | $12^{\prime \prime}$ |
| $66^{\prime}$ | $4^{\prime \prime}$ | $24^{\prime \prime}$ |
| $99^{\prime}$ | $6^{\prime \prime}$ | $36^{\prime \prime}$ |
| $132^{\prime}$ | $8^{\prime \prime}$ | $48^{\prime \prime}$ |



## Slope Adjustment

Instructions: Calculate tape slope distance from the tree.

| Desired Horizontal <br> Distance | Percent Slope <br> From Tree | Taped Distance |
| :---: | :---: | :---: |
| $66^{\prime}$ | $+34 \%$ |  |
| $100^{\prime}$ | $+15 \%$ |  |
| $66^{\prime}$ | $+65 \%$ |  |
| $99^{\prime}$ | $-35 \%$ |  |
| $33^{\prime}$ | $+40 \%$ |  |


| Slope Adjustment Factors in One Percent Increments |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor |
| 5 | 1 | 29 | 1.041 | 53 | 1.132 | 77 | 1.262 | 101 | 1.421 |
| 6 | 1.001 | 30 | 1.044 | 54 | 1.136 | 78 | 1.269 | 102 | 1.428 |
| 7 | 1.002 | 31 | 1.047 | 55 | 1.141 | 79 | 1.275 | 103 | 1.436 |
| 8 | 1.003 | 32 | 1.05 | 56 | 1.146 | 80 | 1.281 | 104 | 1.443 |
| 9 | 1.004 | 33 | 1.054 | 57 | 1.151 | 81 | 1.287 | 105 | 1.45 |
| 10 | 1.005 | 34 | 1.057 | 58 | 1.156 | 82 | 1.293 | 106 | 1.457 |
| 11 | 1.006 | 35 | 1.06 | 59 | 1.161 | 83 | 1.3 | 107 | 1.464 |
| 12 | 1.007 | 36 | 1.063 | 60 | 1.166 | 84 | 1.306 | 108 | 1.472 |
| 13 | 1.008 | 37 | 1.067 | 61 | 1.172 | 85 | 1.312 | 109 | 1.479 |
| 14 | 1.009 | 38 | 1.07 | 62 | 1.177 | 86 | 1.319 | 110 | 1.486 |
| 15 | 1.01 | 39 | 1.074 | 63 | 1.183 | 87 | 1.325 | 111 | 1.494 |
| 16 | 1.012 | 40 | 1.077 | 64 | 1.188 | 88 | 1.332 | 112 | 1.501 |
| 17 | 1.014 | 41 | 1.081 | 65 | 1.194 | 89 | 1.338 | 113 | 1.509 |
| 18 | 1.016 | 42 | 1.085 | 66 | 1.199 | 90 | 1.345 | 114 | 1.516 |
| 19 | 1.018 | 43 | 1.089 | 67 | 1.205 | 91 | 1.352 | 115 | 1.524 |
| 20 | 1.02 | 44 | 1.093 | 68 | 1.21 | 92 | 1.359 | 116 | 1.532 |
| 21 | 1.022 | 45 | 1.097 | 69 | 1.216 | 93 | 1.365 | 117 | 1.539 |
| 22 | 1.024 | 46 | 1.101 | 70 | 1.221 | 94 | 1.372 | 118 | 1.547 |
| 23 | 1.026 | 47 | 1.105 | 71 | 1.227 | 95 | 1.379 | 119 | 1.554 |
| 24 | 1.028 | 48 | 1.11 | 72 | 1.233 | 96 | 1.386 | 120 | 1.562 |
| 25 | 1.031 | 49 | 1.114 | 73 | 1.238 | 97 | 1.393 |  |  |
| 26 | 1.034 | 50 | 1.118 | 74 | 1.244 | 98 | 1.4 |  |  |
| 27 | 1.036 | 51 | 1.123 | 75 | 1.25 | 99 | 1.407 |  |  |
| 28 | 1.039 | 52 | 1.127 | 76 | 1.256 | 100 | 1.414 |  |  |

Distance Correction: Horizontal distance $*$ slope adjustment factor $=$ adjusted slope distance.

## Height Measurement

Instructions: Calculate height using the percent scale.

| Horizontal Distance | Measured | Actual Height |
| :---: | :---: | :---: |
| From Tree | Height |  |
| $85^{\prime}$ | $92^{\prime}$ |  |
| $105^{\prime}$ | $110^{\prime}$ |  |
| $100^{\prime}$ | $113^{\prime}$ |  |
| $75^{\prime}$ | $102^{\prime}$ |  |
| $125^{\prime}$ | $85^{\prime}$ |  |
|  |  |  |

Instructions: Calculate height using the topographic scale

| Horizontal Distance | Measured | Actual Height |
| :---: | :---: | :---: |
| From Tree | Height |  |
| $99^{\prime}$ | $64^{\prime}$ |  |
| $66^{\prime}$ | $51^{\prime}$ |  |
| $132^{\prime}$ | $65^{\prime}$ |  |
| $33^{\prime}$ | $64^{\prime}$ |  |
| $66^{\prime}$ | $62^{\prime}$ |  |

## Relaskop Diameters

Instructions: Determine bar width equivalents.

| Horizontal Distance From Tree 99' | Single Small Bars | Pair of Large bars |
| :---: | :---: | :---: |
| 33 ' |  |  |
| 132' |  |  |
| 66 |  |  |

1. What bars would you use to measure a $28^{\prime \prime}$ diameter at $33^{\prime}$ and $66^{\prime}$ ?
a.
b.

## Relaskop Heights

Class Problem
No. 6

Instructions: Calculate Heights.

| Top <br> Measurement | Stump <br> Measurement | Height |
| :---: | :---: | :---: |
| $+9^{\prime}$ | $-5^{\prime}$ |  |
| $+67^{\prime}$ | $+6^{\prime}$ |  |
| $+25^{\prime}$ | $-32^{\prime}$ |  |
| $+67^{\prime}$ | 0 |  |
| $+75^{\prime}$ | $-6^{\prime}$ |  |

## Form Class

616 Volume Equations require Form Class (FC) to calculate top diameter of the first log. This directly affects the diameters of the remaining logs in the tree, which affects the volume of the whole tree.

Form Class is a ratio of the diameter inside bark (DIB) at the top of the first log to DBH. Form Class takes into account the taper of the first log, from diameter at breast height ( DBH ) to the top of the first $\log$ ( 16.5 ' from stump height).

The more Form Class varies between trees within a species, the more samples will be needed.
Small errors in DOB measurement can cause large differences in Form Class. There is approximately 2-3\% volume difference between Form Classes.

Examples below show how slight differences in measurements can have large differences in Form Class. Note difference between small and large DBH's

Example 1: Small Tree (14.2" DBH)

| Relaskop Bar Measurements | Actual Measurements |
| :---: | :---: |
| $11.0 "$ | $11.5 "$ |
| Form Class: 77 | Form Class: 81 |

Example 2: Large Tree (40.0" DBH)

Relaskop Bar Measurements 30.0"

Form Class: 75

Actual Measurements
30.5"

Form Class: 76

Bark Thickness Ratio (BTR) is the ratio between diameter inside bark (DIB) and diameter outside bark (DOB) at top of the first $\log (\mathrm{DIB} \div \mathrm{DOB})$.

Top DIB can be determined two ways:

1. Measure directly. (Direct).
2. Apply a known BTR. (Limiting Distance \& Bar Scale).

Direct


Example A: $\frac{D I B}{D B H} * 100=F C$

$$
\frac{22}{30} * 100=73
$$

## A Known BTR



Example B: $\frac{D O B * B T R}{D B H} * 100=F C$

$$
\frac{23 * .96}{30} * 100=74
$$

There are three common methods for determining Form Class:

## Direct, Limiting Distance and Bar Scale

## Direct Method for Form Class

1. Measure DOB at the top of the first log with a diameter tape, measure the bark thickness and subtract it from DOB to determine DIB, divide by the DBH, and multiply by 100 to calculate Form Class. This can be done with the use of ladders on standing trees, or by measuring felled or wind thrown trees. This is an excellent way to obtain Form Class, providing there are enough samples.
$\mathrm{FC}=\frac{D I B}{D B H} * 100$

## Limiting Distance Method for Form Class

1. Measure DBH , rounding down to the nearest $1 / 10^{\text {th }}$ inch.
2. Situate the zero end of your loggers tape at about your eye level and directly below the center of the tree at the top of the first log. Note: Project that center from the top of the first log vertically downward to eye level.
3. After correctly positioning the zero end of your loggers tape, measure away from the tree (to the north, for example), until the scale of the Relaskop that comprises 40 BAF (or the appropriate smaller BAF on smaller trees) are the exact same width as the tree at the top of the first log's outside bark. Then, without changing the distance between your head/eye and the tree, measure the distance from the zero end of your tape to your eye, to the nearest one hundredth of a foot and record it. Then repeat this entire procedure to the west or east; 90 degrees from the first reading, as explained above.
4. After repeating the procedure in step 2 and 3 , add both distances together and divide by two to average them.
5. Take the average distance calculated in step 4 and divide it by 1.375 , which is the plot radius factor to the center of the tree for 40 BAF , or use the appropriate plot radius factor for the BAF being used.

- Carry mathematical calculations a minimum of five (5) characters to right of decimal point before rounding.

6. Multiply the result of step 5 by the known BTR, to get the DIB at the top of the first log.
7. Divide the top DIB (result of step 6) by the DBH and multiple by 100 to get the Form Class. Record both the DIB at the top of the first log and FC on the cruise card. Record DIB below the FC in the green comment area.
8. Limiting Distance Formula:

$$
\mathrm{FC}=\frac{\frac{\text { Average Horizontal Dist }}{\text { Plot Radius Factor(to center of tree) }} * \text { Bark Thickness Ratio }}{\text { Diameter Breast Height }} * 100
$$



## Bar Scale Method for Form Class - Using the Relaskop

1. Measure DBH , rounding down to the nearest $1 / 10^{\text {th }}$ inch.
2. Situate the zero end of your loggers tape at about your eye level and directly below the center of the tree at the top of the first log. Note: Project that center from the top of the first log vertically downward to eye level.
3. Move back to a fixed distance with the loggers tape, i.e. $33^{\prime}$ or $66^{\prime}$ from the base of the tree. Inside the Relaskop the scale between " a " and " b " is divided into 6 equal width bars ( 3 light and 3 dark). The projection of the distance " $a$ " to " $b$ " is equal to:

1 foot (each bar 2 inches) at horizontal distance of 33 feet
2 foot (each bar 4 inches) at horizontal distance of 66 feet
4. Sight through the Relaskop at top of the first log. The diameter outside the bark at this point can be measured using the scale bars between "a" and "b". Measure from the left side of the scale to the right. The left side of the scale is placed on the left edge of the bole of the tree and the number of bars to the right is counted and the diameter is estimated to the nearest inch. This measurement becomes the DOB.

Sight from the direction that minimizes tree lean, slope, and brush; preferably a cardinal direction (north, south, east, west). Then repeat this procedure 90 degrees from the first reading. Then average these two readings for the average DOB .
5. The DOB is then multiplied by a known BTR to establish the DIB at the top of the first log. Record both the DIB at the top of the first log and FC on the cruise card. Record DIB below the FC in the green comment area.
6. The DIB is then divided by the DBH and multiplied by 100 to determine the Form Class.
7. Bar Scale Formula: $\quad \mathrm{FC}=\frac{D O B * B T R}{D B H} * 100$


## Form Class

Instructions: Calculate Form Class

1. DBH: $26.5 "$
2. DBH: 32.0"
3. DBH: 18.5 "
4. DBH: 12.3"

DOB: 14.0"

DIB: 24.0"

DOB: 15.0"

DIB: 9.9"

BTR: . 90

BTR: . 80

BTR: . 92

BTR: . 96
FC: $\qquad$

## Notes:

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## Module II - Species and Product Designation

## Species Identification

Tree characteristics to help determine species:
a. Bark color, pattern, and texture.
b. Tree form or shape.
c. Number of needles per fascicle.
d. Length and shape of needles.
e. Cone size and shape.
f. Geographic location.

Species identification is essential due to the different uses and values.

## Species

Ponderosa pine
Douglas-fir
White fir
Lodgepole pine
Non-sawlog

## Delivered Log Price

\$150.00/CCF
\$137.00/CCF
\$125.00/CCF
\$113.00/CCF
\$ 75.00/CCF
\$300.00/MBF
\$275.00/MBF
\$250.00/MBF
\$225.00/MBF
\$150.00/MBF

## Uses

moulding, finished lumber construction (lumber/plywood) plywood core, construction studs, house logs, poles particle board, paper, etc.

## Product Designation

## "Grading"

During recent years, changes in resource management have brought about changes in the type of material that is available to harvest. Smaller size trees and changing markets have created some opportunities to improve our efficiency and accuracy in timber sale preparation. This will help to streamline the timber sale cruising and appraisal process.

Cruiser assigns one of three (3) "grade codes" which corresponds to the product of each log; sawlog, non-sawlog or cull product. Grade each log independently, without considering the grade of other logs in the tree. Logs are evaluated as they appear at the time they are cruised. DO NOT project to what they "might" be at the time of harvest.

| Grade $1=$ Sawlog | Logs that meet sawlog minimum specifications. |
| :--- | :--- |
| Grade $8=$ Non-sawlog | Logs that do not meet sawlog minimum specifications are <br> evaluated for non-sawlog specifications. |
| Grade $9=$ Cull | N/A when non-sawlog products are included in the cruise. |

## Product Determination Procedures

1. Locate each 16 ' $\log$ segment, including trim, in the tree by measuring height.
2. Grade each $16^{\prime} \log$ segment. Segment lengths are the same for cubic and scribner.
3. Assume it is a sawlog product until proven otherwise.
4. Make deductions for any sawlog defects.
5. Non-sawlog products are cruised only for gross volume. No deductions are made for defects on nonsawlog products.

Cruise for sawlog product (Grade 1) first. If sawlog defects exceed the maximum defect $\%$ allowed, the log becomes a non-sawlog product (Grade 8). If non-sawlog products are included in the cruise, product designation of cull (Grade 9) is inapplicable.

If non-sawlog products are not a cruise component, logs not meeting sawlog specifications will become cull (grade 9).

## Merchantability Specifications

Product
Sawlog (Grade 1)
Non-sawlog (Grade 8)
Cull logs (Grade 9)

| Maximum Defect |  |
| :--- | :--- |
| Cubic | $\frac{\text { Scribner }}{66 \%}$ |

Cruise for gross volume only, no defect deductions.
N/A when non-sawlog products are included in the cruise.

## Cubic

Grade 1 - Sawlog (all species)<br>Grading Specifications

Logs shall be suitable for the production of lumber or veneer to an amount of not less than 40 percent of gross cubic foot volume and has a minimum Diameter Inside Bark of 5.0 inches at the small end.

## Grade 8 - Non-sawlog (all species)

Grading Specifications
Logs not meeting the sawlog specifications will be evaluated using non-sawlog specifications.
Logs shall be suitable for the production of any product other than lumber or veneer and have a minimum Diameter Inside Bark of 2.0 inches at the small end. Non-sawlog products will be cruised only for gross volume. No deductions are made for defects on non-sawlog products. Forests may set the minimum top DIB larger than 2".

## Grade 9 - Cull (all species)

Logs not meeting sawlog specifications. N/A when non-sawlog products are included in the cruise.

## Scribner

Grade 1 - Sawlog (all species)<br>Grading Specifications

Logs shall be suitable for the production of lumber or veneer to an amount of not less than 33.3 (34) percent of gross Scribner volume and has a minimum Diameter Inside Bark of 5.0 inches at the small end.

## Grade 8 - Non-sawlog (all species) <br> Grading Specifications

Logs not meeting the sawlog specifications will be evaluated using non-sawlog specifications.
Logs shall be suitable for the production of any product other than lumber or veneer and have a minimum Diameter Inside Bark of 2.0 inches at the small end. Non-sawlog products will be cruised only for gross volume. No deductions are made for defects on non-sawlog products. Forests may set the minimum top DIB larger than 2".

## Grade 9 - Cull (all species)

Logs not meeting sawlog specifications. N/A when non-sawlog products are included in the cruise.

## Species Identification

1. What are four characteristics or factors in helping to determine species identification?
a. $\qquad$
b. $\qquad$
c. $\qquad$
d. $\qquad$

## Product Designation

"Grades"

Class Problem
No. 9

1. Surface characteristics are a factor in product designation grades. $\mathrm{T} \quad \mathrm{F}$
2. Assume a sawlog (Grade 1) until ruled out.

T
F
3. Serious defect could affect product designation.

T F
4. Why is it necessary to determine the location of each log segment? $\qquad$
$\qquad$

## Notes:

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## Module III - Defect Recognition and Deductions

In Region 6, sawlog volume is sold on a basis of net volume; gross volume minus defect deductions establishes net volume.

In Region 6, non-sawlog volume is sold on a basis of gross volume; net volume equals gross volume.

## Sawlog:

- Deductions can be taken in one percent ( $1 \%$ ) increments.
- Deductions are applied to each log segment at the time they are cruised.
- DO NOT project defect to what it "might" be at the time of harvest.
- Consider the extent of defect length in even 2-foot multiples.
- Minimum merchantable length is six (6) feet.


## Non-sawlog:

- Non-sawlog products are cruised only for gross volume. No deductions are made for defects on non-sawlog products.
- Refer to the cruise plan for minimum merchantable length.

Two major classifications of defect deductions are hidden and visible.

- Hidden defects lack external indicators. This, along with anticipated breakage, is accounted for during the cruise input process.
- Visible defect deductions are based on the existence of visible indicators; not hunches or feelings.

Volume loss from visible defect is caused by:

1. natural defects
2. logging/mechanical defects

## Sources of Defects

There are two sources of defects: Natural and Logging/Mechanical.

1. Natural defects exist in the log before the tree is felled. These may include all kinds of interior rot, rotten knots, fire scars, cat faces, lightening scars, massed grub worm holes, bark seams, forks, sap rot, crook and sweep.
2. Logging/mechanical defects are usually caused by machinery or skidded logs rubbing against the base of a tree during a previous logging operation. These defects can also be caused during felling and processing. This may include defects such as breaks, tractor damage, loading and unloading damage.

Defect indicators are visible abnormalities that need further investigation. Cruisers may or may not find defects associated with these indicators.

Examples of defect indicators include:

1. butt swell
2. sap rot
3. conks
4. crook
5. bark seams
6. catface
7. broken tops
8. sucker limbs
9. fire scars
10. insect damage
11. sweep
12. forks

Portions of the tree that can be affected:

1. root and butt
2. heartwood or stem
3. sapwood or perimeter

## Defect Categories

1. Sawlog defects - reduce the amount of lumber or veneer that can be manufactured from a log.

Types of defects include:
a. breaks - partial or complete break in a log
b. checks - internal or external cracks in the log
c. rots - decomposition of wood substance
d. crook - abrupt curve or bend in a log
e. sweep - gradual curve in a log
f. fire scars - injury caused by fire
g. frost cracks - cracks caused from contracting/expanding moisture in trees
h. lightening scars - deduct for any rot, weather checks or massed pitch.
i. voids - no wood present
j. soft rots - rot not usable for any product
k. char - burned wood, charcoal

1. massed pitch - wood impregnated with pitch
m. metal objects-fencing, nails, railroad spikes, horseshoes
2. Non-sawlog defects- no deductions are made for defects on non-sawlog products.

## Cubic

Sawlogs are allowed a maximum of $60 \%$ product defect.


## Scribner

Sawlogs are allowed a maximum of $66 \%$ product defect.


## Rots

Root rots spread underground and destroy the fine root system, which in turn, make trees susceptible to wind throw. Wind thrown trees, caused by root rot, are identified by nubbed off roots.


## Common Root Decays

a. Laminated root rot (Phellinius weirii/Poria werii)
b. Shoestring rot (Armillaria ostoyae)
c. White spongy rot (Fomes annosus)

Butt rot indicators (fruiting bodies/conks) occur near the tree base; sometimes attached. Butt swell often occurs, with volume loss normally limited to a portion of the butt log.


## Common Butt Decay

a. Velvet top or cow-pie (Phaeolus schweinitzii)

Heart rots affect the heartwood (dryer center portions) of the tree, rather that the moist sapwood. Age of the tree and size of conks can be a determining factor as to the extent of damage.


## Common Heart Rots

a. White speck (Phellinus pini/Fomes pini)
b. Indian paint conk (Echinodontium tinctorium)
c. Quinine conk (Lariciformes/Fomes officinalis)
d. Sulfur conk (Laetiporus/Polyporus suphureus)
e. Yellow cap fungus (Pholiota adiposa)
f. Light brown cubical top rot (Fomitopsis cajenderi)

Sap rots affect the moist outer perimeter of the tree bole. Dead trees are the primary hosts.


## Common Sap Rots

a. White pouch fungus (Cryptoporous/Polyporus volvatus)
b. Purple conk (Hirschioporus/Polyporus abietnum)

## Basal/Trunk/Stem Injury Rots

Mechanical injuries often occur when a tree was younger and smaller, usually caused by machinery or skidded logs rubbing against the base of the tree during previous logging operations. Fungi rots are sometimes introduced through these injuries. Basal or stem injuries in contact with the ground are especially susceptible to fungi infection. The severity usually increases with age.

Basal/Trunk injuries appear similar to severe fire scars, with the absence of the char. Fungi rot is almost always associated when in contact with the ground on an old injury. Trunk injuries are not in contact with the ground.


Fire scars appear to be more severe than they really are. Fire will often have a case hardening affect on the tree and limit rot.


Deductions for fire scars, basal, and trunk injuries are made only if there is volume loss. For Scribner, only consider defect penetrating the scaling cylinder.


Lightening scars are a form of trunk injury that may have little or no deduction. Make deductions for rot, weather checks or massed pitch if necessary.

Cubic


Scribner


Frost cracks occur when extremely low temperatures freeze and expand the moisture in trees. Trees with small diameters and species such as true fir with high moisture content are most susceptible. Defect deductions are made for frost cracks and will be more severe for multiple frost cracks.


Broken tops, unless recent, may have associated rot. Stem shatter or rot below the merchantable top should be deducted.


Forks caused from past injuries or genetics will have limited deductions made for the area immediately adjacent to the fork.


Crook and Sweep may require a volume deduction. Sweep is a gradual stem deflection and is less abrupt than crook. Deductions for crook and sweep are made for the void and the portion of the log that will not produce standard length lumber in the manufacturing process. Crook and sweep are defect deductions for sawlogs.


Sawlog Defect Table in Percent

| $\|c\| c\|c\| c\|c\| c\|c\| c \mid$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |$|$

Find the length of your defect along the top row and then the percent of the ( $16^{\prime}$ ) $\log$ affected down the left side. Consider defect length in even 2 -foot multiples for sawlogs.

## Determining Saprot Loss

Consider the following:

1. Needle condition (Dying, dead or missing).
2. Bark condition (Tight, sloughing, missing).
3. Visible checks or indicators.
4. Sap conks present (Age-new or old).
5. Chop to determine extent of decay.

Determine the average depth of decay and then double it, i.e., if you chop at four places and get depths totaling 8 ", divide by 4 , equaling 2 " average defect depth. Double this $2 "$ and find the 4 " depth on the Cubic Perimeter Defecting Guide, with the appropriate small end diameter of the log.

CUBIC PERIMETER DEFECTING GUIDE (07/09)
(DEFECT PERCENT BASED ON 16' LOG VOLUMES)

DEPTH OF DEFECT IN INCHES - 2 SIDES

|  |  | 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 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 5 | 31 | 57 | 75 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| S | 6 | 27 | 50 | 72 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| M | 7 | 25 | 44 | 62 | 74 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A | 8 | 22 | 40 | 57 | 70 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| L | 9 | 19 | 37 | 52 | 65 | 77 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| L | 10 | 18 | 33 | 48 | 60 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 11-12 | 16 | 30 | 43 | 55 | 63 | 72 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| E | 13-14 | 14 | 26 | 38 | 49 | 58 | 65 | 72 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| N | 15-16 | 12 | 23 | 34 | 43 | 52 | 61 | 69 | 73 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| D | 17-18 | 11 | 21 | 30 | 39 | 48 | 54 | 62 | 68 | 75 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 19-20 | 10 | 19 | 27 | 35 | 44 | 51 | 57 | 64 | 69 | 74 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| D | 21-23 | 9 | 17 | 25 | 32 | 39 | 46 | 52 | 58 | 64 | 68 | 73 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| I | 24-26 | 8 | 15 | 22 | 29 | 35 | 41 | 47 | 53 | 58 | 63 | 67 | 72 | 74 |  |  |  |  |  |  |  |  |  |  |  |  |
| A | 27-29 | 7 | 13 | 20 | 26 | 32 | 38 | 43 | 48 | 53 | 57 | 62 | 66 | 70 | 74 | 76 |  |  |  |  |  |  |  |  |  |  |
| M | 30-32 | 6 | 12 | 18 | 24 | 29 | 34 | 39 | 44 | 49 | 53 | 57 | 61 | 65 | 69 | 72 | 75 |  |  |  |  |  |  |  |  |  |
| E | 33-35 | 6 | 11 | 17 | 22 | 27 | 32 | 36 | 41 | 45 | 50 | 53 | 57 | 61 | 64 | 68 | 71 | 74 | 76 |  |  |  |  |  |  |  |
| T | 36-38 | 5 | 10 | 15 | 20 | 25 | 29 | 34 | 38 | 42 | 46 | 50 | 54 | 57 | 61 | 64 | 67 | 70 | 73 | 75 |  |  |  |  |  |  |
| E | 39-41 | 5 | 10 | 14 | 19 | 23 | 27 | 31 | 35 | 40 | 43 | 47 | 50 | 54 | 57 | 60 | 63 | 66 | 69 | 72 | 74 |  |  |  |  |  |
| R | 42-44 | 4 | 9 | 13 | 17 | 22 | 26 | 30 | 33 | 37 | 40 | 44 | 48 | 51 | 54 | 57 | 60 | 63 | 65 | 68 | 71 | 73 | 75 |  |  |  |
|  | 45-47 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 31 | 35 | 38 | 41 | 45 | 48 | 51 | 54 | 57 | 60 | 62 | 65 | 68 | 70 | 72 | 74 | 75 |  |
|  | 48-50 | 4 | 8 | 12 | 15 | 19 | 22 | 26 | 30 | 33 | 36 | 39 | 42 | 45 | 48 | 51 | 54 | 57 | 59 | 62 | 64 | 67 | 69 | 71 | 73 | 75 |
|  |  | 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 |

DEPTH OF DEFECT IN INCHES - 2 SIDES
To use: Determine average depth of perimeter defect; double the defect for both sides; apply to defecting guide to determine defect percent. For sap rot, deduct the full percentage shown. For weather checks, deduct $1 / 2$ the percent shown if straight and deduct the full percent if spiral. If Sawlog defect percent exceeds $60 \%$, the $\log$ becomes a non-saw with no defect.

Example: A 16 inch small end diameter log with straight weather checks, averaging 1.5 inches in depth, affects the whole circumference. A 3 inch depth of defect ( 1.5 inch $\times 2$ sides $=3$ inches) equals $34 \%$. Deduct $1 / 2$ this amount $(34 \% \div 2)$ for a $17 \%$ volume loss.

DEPTH OF DEFECT IN INCHES - 2 SIDES

|  |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 5 | 50 | 50 | 100 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 6 | 0 | 50 | 50 | 100 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 7 | 33 | 33 | 66 | 66 | 100 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 8 | 0 | 33 | 33 | 66 | 66 | 100 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| S | 9 | 25 | 25 | 50 | 50 | 75 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| M | 10 | 33 | 50 | 50 | 66 | 66 | 83 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A | 11 | 14 | 43 | 57 | 57 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| L | 12 | 12 | 25 | 50 | 62 | 62 | 75 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| L | 13 | 20 | 30 | 40 | 60 | 70 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 14 | 8 | 27 | 36 | 45 | 64 | 73 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 15 | 21 | 29 | 43 | 50 | 57 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| E | 16 | 12 | 31 | 37 | 50 | 56 | 62 | 75 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| N | 17 | 11 | 22 | 39 | 44 | 56 | 61 | 66 | 88 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| D | 18 | 14 | 24 | 33 | 48 | 52 | 62 | 66 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 19 | 12 | 25 | 33 | 42 | 54 | 58 | 66 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 20 | 14 | 25 | 36 | 43 | 50 | 61 | 64 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| D | 21 | 7 | 20 | 30 | 40 | 47 | 53 | 63 | 66 | 73 |  |  |  |  |  |  |  |  |  |  |  |  |
| I | 22 | 9 | 15 | 27 | 36 | 45 | 52 | 58 | 66 | 70 |  |  |  |  |  |  |  |  |  |  |  |  |
| A | 23 | 13 | 21 | 26 | 37 | 45 | 53 | 58 | 63 | 71 |  |  |  |  |  |  |  |  |  |  |  |  |
| M | 24 | 5 | 17 | 25 | 30 | 40 | 47 | 55 | 60 | 65 | 72 |  |  |  |  |  |  |  |  |  |  |  |
| E | 25 | 13 | 17 | 28 | 35 | 39 | 48 | 54 | 61 | 65 | 70 |  |  |  |  |  |  |  |  |  |  |  |
| T | 26 | 8 | 20 | 24 | 34 | 40 | 44 | 52 | 58 | 64 | 68 |  |  |  |  |  |  |  |  |  |  |  |
| E | 27 | 9 | 16 | 27 | 31 | 40 | 45 | 49 | 56 | 62 | 67 |  |  |  |  |  |  |  |  |  |  |  |
| R | 28 | 5 | 14 | 21 | 31 | 34 | 43 | 48 | 52 | 59 | 64 | 69 |  |  |  |  |  |  |  |  |  |  |
|  | 29 | 5 | 10 | 18 | 25 | 34 | 38 | 46 | 51 | 54 | 61 | 66 | 70 |  |  |  |  |  |  |  |  |  |
|  | 30 | 8 | 12 | 17 | 24 | 30 | 39 | 42 | 50 | 55 | 58 | 64 | 68 |  |  |  |  |  |  |  |  |  |
| 1 | 31 | 7 | 14 | 18 | 23 | 30 | 35 | 44 | 46 | 54 | 58 | 61 | 66 | 70 |  |  |  |  |  |  |  |  |
| 6 | 32 | 4 | 11 | 18 | 22 | 26 | 32 | 38 | 46 | 49 | 55 | 59 | 62 | 68 |  |  |  |  |  |  |  |  |
|  | 33 | 5 | 8 | 15 | 22 | 26 | 29 | 36 | 41 | 49 | 51 | 58 | 62 | 64 | 69 |  |  |  |  |  |  |  |
| F | 34 | 2 | 7 | 11 | 17 | 24 | 27 | 31 | 37 | 43 | 50 | 52 | 59 | 62 | 65 | 70 |  |  |  |  |  |  |
| 0 | 35 | 8 | 11 | 16 | 19 | 25 | 31 | 34 | 37 | 43 | 48 | 55 | 57 | 62 | 66 | 68 |  |  |  |  |  |  |
| 0 | 36 | 4 | 13 | 15 | 20 | 23 | 28 | 34 | 37 | 40 | 46 | 50 | 57 | 59 | 64 | 67 |  |  |  |  |  |  |
| T | 37 | 11 | 15 | 22 | 24 | 28 | 31 | 36 | 41 | 44 | 47 | 51 | 55 | 61 | 63 | 68 |  |  |  |  |  |  |
|  | 38 | 4 | 14 | 18 | 25 | 27 | 31 | 34 | 38 | 43 | 46 | 49 | 53 | 57 | 64 | 69 |  |  |  |  |  |  |
|  | 39 | 4 | 8 | 18 | 21 | 29 | 30 | 34 | 37 | 41 | 46 | 48 | 51 | 55 | 59 | 64 | 66 | 71 |  |  |  |  |
| L | 40 | 7 | 11 | 14 | 23 | 27 | 33 | 35 | 38 | 41 | 45 | 49 | 52 | 54 | 58 | 62 | 66 | 68 |  |  |  |  |
| O | 41 | 6 | 12 | 16 | 19 | 28 | 31 | 37 | 39 | 42 | 44 | 48 | 52 | 54 | 57 | 61 | 64 | 69 |  |  |  |  |
| G | 42 | 5 | 10 | 16 | 20 | 23 | 31 | 34 | 40 | 42 | 45 | 47 | 51 | 54 | 57 | 59 | 63 | 66 | 70 |  |  |  |
|  | 43 | 4 | 9 | 14 | 20 | 24 | 26 | 34 | 37 | 43 | 44 | 47 | 49 | 53 | 56 | 59 | 61 | 64 | 67 |  |  |  |
|  | 44 | 5 | 9 | 14 | 19 | 24 | 28 | 30 | 38 | 41 | 46 | 47 | 50 | 52 | 55 | 59 | 61 | 63 | 66 | 69 |  |  |
|  | 45 | 3 | 8 | 12 | 16 | 21 | 26 | 30 | 32 | 39 | 42 | 47 | 49 | 51 | 53 | 57 | 60 | 62 | 64 | 67 |  |  |
|  | 46 | 4 | 7 | 12 | 16 | 20 | 25 | 30 | 33 | 35 | 42 | 45 | 50 | 51 | 53 | 55 | 58 | 62 | 64 | 65 | 69 |  |
|  | 47 | 4 | 8 | 11 | 16 | 19 | 23 | 28 | 33 | 36 | 38 | 45 | 47 | 52 | 53 | 55 | 57 | 60 | 63 | 65 | 67 |  |
|  | 48 | 4 | 8 | 12 | 14 | 19 | 23 | 27 | 31 | 35 | 38 | 40 | 47 | 49 | 54 | 55 | 57 | 59 | 62 | 65 | 66 | 68 |
|  | 49 | 4 | 8 | 12 | 16 | 18 | 22 | 26 | 29 | 33 | 38 | 41 | 43 | 49 | 51 | 56 | 57 | 59 | 61 | 63 | 66 | 68 |
|  | 50 | 4 | 7 | 11 | 15 | 19 | 21 | 25 | 28 | 32 | 36 | 40 | 43 | 45 | 51 | 53 | 57 | 58 | 60 | 62 | 65 | 67 |
|  |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |

DEPTH OF DEFECT IN INCHES - 2 SIDES
To use: Determine average depth of perimeter defect on the small end of a 16 ' log; double the defect for both sides; apply to defecting guide to determine defect percent. For sap rot and weather checks, deduct the full amount shown. If Sawlog defect percent exceeds $66 \%$, the $\log$ becomes a non-saw with no defect.

Examples: A 16 -inch small end diameter log has sap rot averaging 1.5 inches in depth and affects the whole log circumference. 1.5 inches x 2 sides $=3$ inches. Defect percent is $37 \%$. A 25 -inch small end diameter log has weather checks that penetrate 4 inches in depth and affect the whole $\log$ circumference. 4 inches x 2 sides $=8$ inches. Defect percent is $61 \%$.

## Char

(Sawlog)
Procedures: Determine if char is present in the wood fiber. If no, then no deduction for char is needed. If char is present in the wood fiber then:

1. Determine extent of defect considering:
a. Length affected
b. Circumference affected
c. Depth affected
2. Determine defect method to use.

## Examples:



Use a \% of the appropriate full perimeter deduction.


Use a \% of length deduction. Length of deduction is considered in $2^{\prime}$ multiples.
Example:
A fire scar extending 3 ' would be a $4^{\prime}$ length deduction for the depth affected.

## Defect

## Class Problem

No. 10

1. What are the two primary causes of visible defect?
a.
b. $\qquad$
2. Defect deductions can be made if you just know there is defect, but there are no visible indicators.

$$
\mathrm{T}
$$

F
3. What are the three areas of the tree affected by rot?
a.
b. $\qquad$
c.
4. Name five types of defect a cruiser should deduct for in a sawlog (Grade 1).
a. $\qquad$
b. $\qquad$
c. $\qquad$
d. $\qquad$
e. $\qquad$
5. Name six visible defect indicators.
a.
b.
c.
d. $\qquad$
e.
f. $\qquad$
6. When non-sawlog products are included in the cruise, when can a non-sawlog become a cull (Grade 9).
a.

## Insert Divider Page Here

## Module IV - Sampling Methods

Because we deal with so many trees, it is usually not practical to measure all of them. This would be very expensive, and as the number of measurements increases, each measurement becomes less reliable. Most often we sample a relatively small number of trees and expand the volume information and apply it to the entire sale.

Sampling reduces the number of overall measurements and saves time and money.


Each measured tree $\qquad$ represents many other trees.

In simplest terms, if all trees on a sale were exactly the same size, we could count them all and measure one to obtain an accurate volume estimate. In reality, we deal with a complex variety of species, sizes, and distribution. Therefore, we need different sampling methods and intensities to estimate volume and value of large stands.

In general, the greater the variability within a sale, the more samples are needed to make an accurate estimate.

Four commonly used sampling methods in Region 6 are:

1. Sample Tree - Sampling with Equal Probability
2. 3P - Probability Proportional to Prediction
3. Fixed Plot - Equal Chance with every other tree in the stand of being sampled
4. Point Sample- Probability Proportional to Size

Another type of cruising often used is a $\mathbf{1 0 0}$ Percent cruise where every tree is cruised. This is commonly used in small populations of trees, trespass cruises, damaged trees, and minor or high value species.


Sample Tree<br>(Individual Tree)

In Sample Tree cruising, trees are randomly selected for measure, with each tree having an equal chance of being selected. This is called Sampling with Equal Probability. Sample frequency is usually described as 1 in 50,1 in 100, etc., meaning that, on an average, 1 out of 50 or 1 out of 100 trees will be cruised. Random selection of trees to be cruised will be achieved using a Random Number list or a data recorder. The use of dice, poker chips, marbles, etc., is not acceptable methods of selecting samples. In many cases, the frequency may be different for each species and size class. This is usually 25-30 samples per species or 15 per sample group if multiple sample groups are present in each species.

The number of cruise trees (samples) needed is based on the difference (variability) in tree-to-tree net volume. The variable of interest in Sample Tree cruising is "Net Volume per Tree".

This is a tree based cruise and is not dependent on acreage.
It is necessary to know the total number of trees being harvested; so accurate tree counts are essential.
Two most common ways to avoid bias in Sample Tree cruising is:

1. Only mark and call out one tree at a time.
2. Use a Random Number list or a Data Recorder controlled by a tally person to select the cruise trees.

Summary of Sample Tree Cruising

1. Each tree has an equal chance of being selected.
2. Total numbers of cut trees are counted by species.
3. Marking and cruising are usually in conjunction.
4. Tree selection bias is easily introduced. Cruisers must not pre-select measure trees.
5. Variability between individual tree net volumes determines sample size.
6. This type of sampling is best suited to sales where cut trees are marked. It may also be appropriate in small clear cuts.

Procedures for Sample Tree Cruising

1. Tree is marked for cut.
2. Tree (species) is called out to a tally person and compared to a random number to determine if measured.
3. Tree is counted.
4. If the tree is a sample tree, it is cruised and monumented for check cruising. Monumentation procedures shall be described in the cruise plan.

## Sample Tree

Class Problem

No. 11

1. List two methods of minimizing bias in selecting cruise trees when Sample Tree cruising.
a. $\qquad$
b. $\qquad$ .
2. Each tree to be harvested must be counted.

$$
\begin{array}{ll}
\mathrm{T} & \mathrm{~F}
\end{array}
$$

3. If your sale had a lot of variability in the tree-to-tree net volumes, fewer samples would be required.

T F
4. Equal probability is the same as each tree having an equal chance of being selected for measure.

T F
5. Describe how a Sample Tree cruising system operates.

## 3P

3P stands for Probability Proportional to Prediction. Volume (most commonly used) or value of each tree to be harvested is estimated by the cruiser. The cruiser usually estimates diameter and/or height and uses a table that converts these estimates to local volume. This estimate is called KPI.
This KPI is compared to a random number. When the KPI is equal to, or larger than the random number, the tree is cruised.

A larger predicted volume increases the chance of the tree being selected; so larger trees are cruised more often than small ones. The variable of interest in 3P sampling is "Measured to Predicted Volume".
$\mathbf{K}$ is the largest number in the random number list and represents the expected volume of the largest tree in the cruise. Any tree with a KPI larger the K must be $100 \%$ cruised. Trees $100 \%$ cruised are termed "Sure to Measure" trees.

The number of cruise trees (samples) needed is $25-30$ per species.
The total number of trees marked for harvest and the estimated volume (KPI) of each are recorded.
This is a tree based cruise and is not dependent on acreage.

## Summary of 3P Cruising

1. Each tree to be harvested must be counted by species.
2. Cruisers estimate diameter and/or height and use a table that lists an estimated volume (KPI).
3. Larger trees have a greater chance of being selected.
4. The more consistent the KPI is, the fewer the cruise trees required. Estimates can be low or high, but if consistent, fewer cruise trees are required.
5. Cruisers must not know the next random number, as this could influence (bias) the estimated volume (KPI). Once a KPI has been called, do not alter that estimate. To do so would bias the cruise.
6. Non-sawlog and/or cull trees are excluded from the 3P sample and are cruised separately if determined to be either before the KPI is called.
7. 3P cruising is best suited in units where variability in tree size or volume per acre is high. It is particularly efficient when cut tree marking.
8. Downfalls of $3 P$ cruising: If units change by adding or deleting areas, the payment unit or sale may need to be recruised. If your cruise does not meet your desired error, you may need to recruise the payment unit or the entire sale.

## Procedures for 3P Cruising

1. Tree to be harvested is marked.
2. Diameter and/or height are estimated and a table is used to estimate the volume (KPI).
3. KPI is compared to a random number and recorded. If the KPI is equal to, or larger than the random number, the tree is cruised.
4. Non-sawlog and/or cull trees are not knowingly included in the 3P sample.
5. Cruise trees are measured and monumented for check cruising. Monumentation procedures shall be described in the cruise plan.

Sales or units having a high percentage of defects require a higher number of cruise trees (samples) due to the greater difference between estimated gross volume (KPI) and measured net volume. This is why cull trees are excluded from the 3P sample.

No. 12

1. The cruiser estimates $\qquad$ and/or $\qquad$ of each tree to be harvested. A table is used to convert these estimates to volume. The estimated volume is called a
$\qquad$ .
2. Larger trees have a better chance of being selected as cruise trees than small trees.
T
F
3. In 3P cruising, units must be traversed to get accurate acreages for computing timber sale volume.

$$
\mathrm{T} \quad \mathrm{~F}
$$

4. The cruiser should know the next random number before the volume is estimated.

$$
\mathrm{T} \quad \mathrm{~F}
$$

## Monumentation

Proper monumentation is important to insure relocation by cruiser, relocation for inspections by purchasers, to facilitate check cruising and for limiting distance measurements.

## Tree Based (STR and 3P) and 100\% Cruises

1. Monument all cruise trees to make them highly visible.
2. Map locations of all cruise trees.
3. At a minimum, each cruise tree shall be identified with ribbon and painted number.
4. Ribbon may be hung in a triangle around each sample tree. See cruise plan for direction.

## Area Based Cruises (Fixed, Point and all variations)

1. Monument all cruise starting points (control points) and point/plot locations to make them highly visible.
2. Intervisible flagging may be hung between plots. See cruise plan for direction.
3. File written descriptions of the control point and point/plot locations with the cruise information.
4. Identify point/plot centers with sturdy stake or pin flagging. (Pin flags not recommended as they can easily be pulled up and/or lost and determination of limiting distance is difficult.
a. If wood stakes are used:

- Stakes must be stationary; driven into the ground so they won't change positions or get knocked over.
- Stakes are to have an " $X$ " marked on top of the stake. The center of the " $X$ " is the point to measure to when measuring limiting distance.
- Stake should be flagged for visibility. The flag should be wrapped and tied.
b. All point/plot centers should include the following:
- The cruiser's initials.
- Unit and point/plot number.
- Distance and direction to the next point/plot.
- Whether the point/plot is a count or measure.

5. Flagging should be hung in a triangle around the point/plot center.
6. Number each measure and count tree clockwise starting from north. Painted tree numbers will face the plot center.
7. Map plot locations.

Point/Plot Monumentation


## Fixed Plot

This is an area dependent sampling method which uses numerous plots of the same size laid out on a systematic grid to provide even distribution of the plots. Accurate acreage determination is important; total number of trees in the sale is not a factor. Each tree in the sale has an equal chance with every other tree in the stand of being sampled.

The plots may be circular (most common), rectangular, or square in shape. The size of each plot has a specified area and is usually referred to as a $1 / 5^{\text {th }}$ acre, $1 / 10^{\text {th }}$ acre, etc. The number of plots needed in a unit is based on the variability in the volume per plot.

All trees within each plot boundary that meet merchantability specifications are measured. By measuring all trees within a plot of known area, the cruiser determines the average volume per acre. The average volume per acre is multiplied by the unit acres to determine the total volume in the unit. The variable of interest in Fixed Plot sampling is "Net Volume per Acre".

Average volume/acre $*$ unit acres $=$ total unit volume.

## Procedures for Fixed Plot Cruising

1. The cruiser is given unit maps and plot information including compass bearing, plot size, number and distance between plots.
2. Establish the specified number of plots in an unbiased manner over the tract of timber to be cruised. Plots are usually laid out on a square grid pattern to facilitate even coverage and reduce the possibility of bias selection of plot location. Establish a starting point that will act as a control point. This should be a permanent fixture or location that is easy to relocate. Clearly monument the control point and record its location. The location of the first plot can be randomly selected by measuring from the control point. Clearly monument each plot location. Establish distance between plots by measuring, not pacing.
3. Follow instructions for monumentation included in this workbook.
4. Determine circular plot boundaries by measuring the radius from the marked plot center. Establish plot boundaries by measuring, not pacing. Radius in feet of common size plots are $1 / 5^{\text {th }}=52.66 \mathrm{ft}$., $1 / 10^{\text {th }}=37.24 \mathrm{ft}$.
5. Plot Radius (PR) is adjusted for slope to insure the correct area is being measured. Use Slope Adjustment Factor table in this work book or the Region 6 Tatum Aids.

Adjusted Plot Radius $=$ Plot Radius $*$ Percent (\%) Slope Adjustment Factor.

Example of square grid pattern for plot location.

Unit 3
Plot size $=1 / 10^{\text {th }}$ acre .
Plot radius $=37.24^{\prime}$
Plot spacing $=400^{\prime}$


## 1/10 ${ }^{\text {th }}$ Acre Plot



- Trees that are $1 / 2$ or more within the plot boundary at DBH are In trees.
- Trees that are less than $1 / 2$ within the plot boundary at DBH are Out trees.
- Trees are In or Out depending on tree DBH in relation to the plot center, not the base of the tree.
- Trees are measured to the center of the bole at DBH.
- Measure all borderline trees for limiting distance. Borderline trees are trees that are not positively identified as clearly being In or Out.

6. Borderline trees are measured to determine if they are In or Out using limiting distance. Follow step-by-step instructions on how to measure limiting distance included in this workbook


- If the plot boundary passes through the center of the tree at DBH, not the base of the tree, count the tree In. In addition, the base of a leaning tree may be outside the plot boundary and the tree can still be considered in.

- If a tree forks below DBH , only the fork(s) within the boundary is included.

- If a tree forks above DBH , include the tree if the plot boundary passes through the center of the tree at DBH.

- Down trees or broken off trees are included if the DBH is on or inside the boundary.

7. If any portion of the plot extends outside the unit boundary, use the Mirage Method to determine the trees to measure. Follow detailed instructions included in this workbook.
8. All trees within the plot boundary that meet merchantability specifications are measured and numbered. Numbering each tree is needed for check cruising. Prior to leaving each plot, edit your data to insure that all needed information is recorded.
9. After completing one line of plots, check the location relative to the unit boundary. Errors in the use of compass or an inaccurate map need to be caught early and adjustments made to correct these errors.

## FIXED Plot

There are two types of Fixed Plot Sampling: FIXED and FCM (Fixed Count Measure).

1. In FIXED, all In trees are measured on every plot.
2. In FCM, there are two types of plots, "measure plots" and "count only plots".
a) On measure plots, all or a portion of the In trees are cruised and all remaining trees (if any) on the measure point are counted and recorded separately by species.
b) On count only plots, every In tree is counted and recorded by species.

## Summary of Fixed Plot

1. Fixed Plot method of cruising is an area based sampling method.
2. This sampling method determines average volume per acre and is best suited where the volume per acre is uniform.
3. All units must be accurately traversed or GPS'd to determine acreage. String devices (hip chains) are not approved for use in traversing.
4. Each tree in the sale has an equal chance of being cruised.
5. The variability of volume per plot determines how many plots are needed.
6. Plots can be circular, rectangular, or square and are of a specified area such as $1 / 5$ th acre and are the same size within each unit.
7. Bias is introduced if the cruiser purposely selects the location of plot centers or does not correct for slope in their measurements.
8. Use Mirage Method if any portion of the plot extends outside the unit boundary.
9. Monument all plot centers as described in this workbook.

## Fixed Plot

Class Problem

No. 13

1. What are the acceptable shapes of plots?
a. $\qquad$ .
b. $\qquad$
c. $\qquad$
2. Are all plots in a unit the same size?
Yes No
3. Cruiser determines volume per plot.

$$
\begin{array}{ll}
\mathrm{T} & \mathrm{~F}
\end{array}
$$

4. Both the acreage harvested and the total number of trees must be known to determine volume in the timber sale.

$$
\begin{array}{ll}
\mathrm{T} & \mathrm{~F}
\end{array}
$$

5. The plot boundary location is estimated.

$$
\begin{array}{ll}
\mathrm{T} & \mathrm{~F}
\end{array}
$$

6. It is not necessary to compensate for slope when cruising fixed plots.

$$
\begin{array}{ll}
\mathrm{T} & \mathrm{~F}
\end{array}
$$

7. Every merchantable tree within the plot must be numbered to assist check cruising.

$$
\begin{array}{ll}
\mathrm{T} & \mathrm{~F}
\end{array}
$$

8 If the plot boundary passes through the center of the tree at stump height, it is considered In. T F

## Procedures for Measuring Borderline Trees

## Fixed Plot

On circular plots, limiting distance is the maximum distance a tree can be from plot center and still be "In". On square and rectangular plots, limiting distance is the maximum distance a tree can be perpendicular from the centerline of the plot.

1. Measure DBH , rounding down to the nearest $1 / 10^{\text {th }}$ inch.
2. Measure percent of slope from DBH , at face of tree, to plot center.
3. Measure slope distance from face of tree, at DBH , to plot center, rounding down to the nearest $1 / 100^{\text {th }}$ foot.
4. Calculate slope limiting distance to $1 / 100^{\text {th }}$ foot (horizontal distance adjusted for slope).
5. If measured slope distance is Equal To or Less Than slope limiting distance, tree is In.
[PR- (DBH/24)] * Slope Adjustment Factor = Slope Limiting Distance ( 24 converts inches to feet and considers one half the diameter)

- Carry calculations a minimum of five (5) characters to the right of decimal point before final rounding. When final rounding, use one character to the right of the desired accuracy. When rounding to two decimal places, evaluate the third.



## Limiting Distance for Fixed Plot

Class Problem
No. 14
The Horizontal Plot Radius for a $1 / 10^{\text {th }}$ acre Circular Fixed Plot is 37.24 feet.
[PR-(DBH/24)] * Slope Adjustment Factor = Slope Limiting Distance

| Tree | Plot |  | Slope <br> Adjustment <br> Factor <br> No. | Radius | DBH/24 | Slope <br> Limiting <br> Distance | Measured <br> Slope <br> Distance |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |


| Slope Adjustment Factors in One Percent Increments |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \text { \% } \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \text { \% } \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor |
| 5 | 1 | 29 | 1.041 | 53 | 1.132 | 77 | 1.262 | 101 | 1.421 |
| 6 | 1.001 | 30 | 1.044 | 54 | 1.136 | 78 | 1.269 | 102 | 1.428 |
| 7 | 1.002 | 31 | 1.047 | 55 | 1.141 | 79 | 1.275 | 103 | 1.436 |
| 8 | 1.003 | 32 | 1.05 | 56 | 1.146 | 80 | 1.281 | 104 | 1.443 |
| 9 | 1.004 | 33 | 1.054 | 57 | 1.151 | 81 | 1.287 | 105 | 1.45 |
| 10 | 1.005 | 34 | 1.057 | 58 | 1.156 | 82 | 1.293 | 106 | 1.457 |
| 11 | 1.006 | 35 | 1.06 | 59 | 1.161 | 83 | 1.3 | 107 | 1.464 |
| 12 | 1.007 | 36 | 1.063 | 60 | 1.166 | 84 | 1.306 | 108 | 1.472 |
| 13 | 1.008 | 37 | 1.067 | 61 | 1.172 | 85 | 1.312 | 109 | 1.479 |
| 14 | 1.009 | 38 | 1.07 | 62 | 1.177 | 86 | 1.319 | 110 | 1.486 |
| 15 | 1.01 | 39 | 1.074 | 63 | 1.183 | 87 | 1.325 | 111 | 1.494 |
| 16 | 1.012 | 40 | 1.077 | 64 | 1.188 | 88 | 1.332 | 112 | 1.501 |
| 17 | 1.014 | 41 | 1.081 | 65 | 1.194 | 89 | 1.338 | 113 | 1.509 |
| 18 | 1.016 | 42 | 1.085 | 66 | 1.199 | 90 | 1.345 | 114 | 1.516 |
| 19 | 1.018 | 43 | 1.089 | 67 | 1.205 | 91 | 1.352 | 115 | 1.524 |
| 20 | 1.02 | 44 | 1.093 | 68 | 1.21 | 92 | 1.359 | 116 | 1.532 |
| 21 | 1.022 | 45 | 1.097 | 69 | 1.216 | 93 | 1.365 | 117 | 1.539 |
| 22 | 1.024 | 46 | 1.101 | 70 | 1.221 | 94 | 1.372 | 118 | 1.547 |
| 23 | 1.026 | 47 | 1.105 | 71 | 1.227 | 95 | 1.379 | 119 | 1.554 |
| 24 | 1.028 | 48 | 1.11 | 72 | 1.233 | 96 | 1.386 | 120 | 1.562 |
| 25 | 1.031 | 49 | 1.114 | 73 | 1.238 | 97 | 1.393 |  |  |
| 26 | 1.034 | 50 | 1.118 | 74 | 1.244 | 98 | 1.4 |  |  |
| 27 | 1.036 | 51 | 1.123 | 75 | 1.25 | 99 | 1.407 |  |  |
| 28 | 1.039 | 52 | 1.127 | 76 | 1.256 | 100 | 1.414 |  |  |

## Point Sampling

Point Sampling is also referred to as Variable Point Sampling.
This is an area dependent sampling method that bases the probability that a tree will be selected for sampling in proportion to its own basal area, or Probability Proportional to Size. This means the larger the tree, the greater chance it has to be selected as a sample. Accurate acreage determination is important; total number of trees in the sale is not a factor.

Numerous sample points are laid out on a systematic grid to provide even distribution of the points. The number of points needed in a unit and the spacing between the points is based on the variability in volume per acre. Each tree around the point center is compared to an angle gauge, usually a wedge prism or a Relaskop at DBH. If the DBH of the tree is larger than the angle projected by the gauge, the tree is selected for sampling.

The volume and basal area of the sample trees are calculated to establish the volume-basal area ratio. Using the basal area per acre and volume-basal area ratio, volume per acre and unit volume can be computed. The variable of interest in Variable Point sampling is "Net Volume per Acre".

Volume/acre * unit acres $=$ total unit volume.

Basal Area (BA) is the square foot area of a tree measured at DBH.
Formulas to calculate basal area: $\mathrm{BA}=\mathrm{DBH}^{2} \mathrm{x} .005454$
or

$$
\mathrm{BA}=3.1416 \times(1 / 2(\mathrm{DBH} / 12))^{2}
$$



- Cross-section of tree with 18 " DBH. Basal area of this tree is $1.77 \mathrm{sq} . \mathrm{ft}$.

Each sample tree, regardless of its actual diameter, represents a constant basal area per acre. This constant is called the basal area factor (BAF) of the critical angle. Each In tree represents the BAF or a constant square foot of basal area per acre.


- Think of each tree as having its own plot around the tree itself. The BAF sets the trees plot size. When the point center is within the "trees plot", the tree is In.

The higher the BAF, the larger the angle, the larger or closer to the point center the tree must be in order to be sampled. A larger BAF (larger angle) results in fewer trees being selected. A BAF is selected that gives an average of 4-8 trees per point. Commonly used BAF's are 5, 10, 20 and 40.


- Trees must be equal to or larger than the critical angle to be In. Using 20 BAF, 5 trees are In. Each In tree, regardless of its diameter, represents 20 sq. ft. of basal area per acre, totaling $100 \mathrm{sq} . \mathrm{ft}$./acre.

Two different BAF's can be used on the same plot as long as each set of data is input into separate strata, i.e., 10 BAF for small trees and 40 BAF for larger trees.

Borderline trees are measured to determine if they are In or Out using limiting distance. Follow step-by-step instructions on how to measure limiting distance included in this workbook.

## Point Sampling

There are two types of point sampling: Point (PNT) and Point, Count, Measure Tree (PCM).

1. In PNT, all In trees are measured on every point/plot.
2. In PCM, there are two types of points/plots, "measure points" and "count only points".
a) On measure points, all or a portion of the In trees are cruised and all remaining trees (if any) on the measure point are counted and recorded separately by species.
b) On count only points, every In tree is counted and recorded by species.
3. The cruiser is given unit maps and point information including compass bearing, BAF, number of measure/count points and distance between them.
4. Points are laid out on a square grid pattern to facilitate even coverage and reduce the possibility of bias selection of their location. Establish a starting point that will act as a control point. This should be a permanent fixture or location that is easy to relocate. Clearly monument the control point and record its location. The location of the first point can be randomly selected by measuring from the control point. Clearly monument each point location. Establish distance between points by measuring, not pacing.
5. Follow instructions for point/plot monumentation included in this workbook.
6. At each sample point location check each tree with an angle gauge, wedge prism or Relaskop for its size at DBH. If the tree is larger than the angle selected for the strata, the tree is In and will be measured or counted. The probability of the tree being selected as a sample is proportional to its basal area. The larger the tree, the more basal area it has, so the greater chance it has to be selected.
7. Borderline trees are measured to determine if they are In or Out using the limiting distance method. Follow step-by-step instructions on how to measure limiting distance included in this workbook.
8. Plot Radius Factor (PRF) is a constant for each BAF that is multiplied by DBH to determine limiting distance. Use PRF table in the Tatum Aid.
9. All trees selected for sampling are measured or counted and numbered. Numbering each tree is needed for check cruising. Prior to leaving each point, edit your data to ensure that all the needed information is recorded.
10. After completing one line of points, check the location relative to the unit boundary. Errors in the use of compass or an inaccurate map need to be caught early and adjustments made to correct those errors.

## Summary of Point Sampling

1. Point Sampling method of cruising is an area based sampling method.
2. This sampling method determines average volume per acre and is best suited where the volume per acre is uniform.
3. All units must be accurately traversed or GPS'd to determine acreage. String devices (hip chains) are not approved for use in traversing.
4. The probability of a tree being selected as a sample is proportional to its basal area. The larger the tree, the more basal area it has, and so the greater the chance it has of being selected.
5. The variability of volume per acre determines how many points are needed.
6. BAF determines which trees will be selected for sampling.
7. For a given critical angle, each sample tree, regardless of its size, is equal to a constant basal area per acre. This constant is called the basal area factor.
8. Trees that are not obviously In or Out are called borderline trees. Measure limiting distance on all borderline trees.
9. On down trees, measure the limiting distance from the face of the tree at DBH to plot center.
10. Bias is introduced if the cruiser purposely selects the location of point centers or does not correct for slope in measurements.
11. Monument all point centers as described in this workbook.

## The Spiegel Relaskop

The Spiegel Relaskop is the most widely used tool for sample tree selection. Bars inside the Relaskop are used to represent different Basal Area Factors (BAF's). The Relaskop automatically adjusts for slope and the internal bar width varies to compensate for slope. When measuring heights, the Relaskop does not adjust for slope distance. When a tree diameter is larger than the critical angle of the Relaskop, the tree is selected for sampling.

Relaskop Bars - Bar 5, 10, 20, and 40 are labeled.


Looking through the Relaskop at DBH, the tree must be larger than the width of the bars for any given BAF to be considered In.

This tree is In using a 5 or 10 BAF, borderline using a 20 BAF, and Out using a 40 BAF.


Smaller trees must be closer to point center in order to be considered In.

Graduating tree sizes using 20 BAF


Borderline trees are measured to determine In or Out status. Borderline trees are hidden trees or trees that are not positively identified as being clearly In or Out.

## Point Sampling

Class Problem
No. 15

1. Larger trees have a greater chance of being selected as sample trees.

T F
2. Cruiser does not have to measure plot boundaries when point sampling.
T F
3. In order to be selected as a sample tree, a tree with a 20 " DBH must be closer to point center when a 10 BAF is used than when a 40 BAF is used.
T F
4. It is not necessary to measure limiting distance on borderline trees.

T F
5. Point sampling determines volume per acre.

$$
\mathrm{T} \quad \mathrm{~F}
$$

6. No trees are measured on count points.

$$
\mathrm{T} \quad \mathrm{~F}
$$

7. What does BAF stand for?

## Procedure for Measuring Borderline Trees Point Sampling

Limiting distance is the maximum distance a tree can be from point/plot center and still be an In tree.

1. Measure DBH , rounding down to the nearest $1 / 10^{\text {th }}$ inch.
2. Measure percent of slope from DBH , at face of tree, to point center.
3. Measure slope distance from face of tree, at DBH , to point center, rounding down to the nearest $1 / 100^{\text {th }}$ foot.
4. Calculate slope limiting distance to $1 / 100^{\text {th }}$ foot (horizontal distance adjusted for slope).
5. If measured slope distance is Equal To or Less Than slope limiting distance, tree is In.

- Carry calculations a minimum of five (5) characters to right of decimal point before final rounding. When final rounding use one character to the right of the desired accuracy. When rounding to two decimal places, evaluate the third.


Example: $\quad$ DBH $*$ PRF $*$ Slope Adjustment Factor $=$ Slope Limiting Distance
Horizontal Limiting Distance $=16.4 " * 1.902=31.19280$ '
Slope Limiting Distance $=31.19280^{\prime} * 1.060=33.064368^{\prime}=33.06$
Measured Slope Distance: 35.40 '
Slope Limiting Distance: 33.06'
Tree is Out by 2.34,
or
Calculate the Slope Limiting Distance using the Adjusted Plot Radius Factor found in the Tatum Aids.
DBH * Adjusted Plot Radius Factor $=$ Slope Limiting Distance

$$
16.4 * 2.0161=33.06404^{\prime}=33.06^{\prime}
$$

1. Is this tree In or Out using a 10 BAF:

2. What is the Horizontal Limiting Distance of these trees to the face of the tree?

| DBH | BAF | Limiting Distance |
| :--- | :---: | :--- |
| 23.4 | 10 |  |
| 10.8 | 20 |  |
| 18.6 | 5 |  |
| 12.3 | 40 | - |

Plot radius factor to face of tree:

| BAF | PRF |
| :---: | :--- |
| 5 | 3.847 |
| 10 | 2.708 |
| 20 | 1.902 |
| 40 | 1.333 |

3. What is the slope limiting distance of the tree shown below? $\qquad$

Is the tree $\mathbf{I n}$ or Out? $\qquad$ .

20 BAF
PRF $=1.902$
Slope Adjustment Factor $=1.097$
or
Adjusted Plot Radius Factor $=2.0865$


## Limiting Distance for Point Sampling

Class Problem

No. 17

DBH * Adjusted Plot Radius Factor $=$ Slope Limiting Distance

| Tree <br> No. | BAF | $\begin{gathered} \% \\ \text { Slope } \end{gathered}$ | DBH | * | $\begin{gathered} \text { Adjusted } \\ \text { PRF }^{1} \end{gathered}$ | Slope <br> Limiting <br> Distance | Measured Slope Distance | In |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 10 | 66 | 16.7 | * | 3.2469 |  | 54.26' |  |
| 2 | 20 | 23 | 62.1 | * | 1.9515 |  | 121.00' |  |
| 3 | 40 | 31 | 24.6 | * | 1.3957 |  | 34.49' |  |

${ }^{1}$ Complete tables of Adjusted Plot Radius Factors from $0 \%$ to $100 \%$ slope are found in the Tatum Aids.

## Mirage Method for Boundary Overlap on Fixed Plots

## 1. Establish Plot Center.

2. Record all trees in the plot that meet merchantability specifications and are within the unit.
3. Measure shortest horizontal distance from plot center to unit boundary. The unit boundary is defined as a straight line between boundary tags.
4. On this same line, measure an equal horizontal distance outside unit boundary.
5. Establish a Mirage Plot center at that distance.
6. Record again all trees that are within the Mirage Plot radius that extends into the original plot within the unit.

Original Plot


- Original plot includes 4 trees.


# Mirage Method for Boundary Overlap on Fixed Plots 

## Mirage Plot



- Mirage plot contains tree \#4 from the original plot and would be double tallied.

When fixed plot cruising, Mirage Plots will be recorded on the cruise card as shown below.

## R6 FScruiser TREE CARD



## Mirage Method for Boundary Overlap on Points

1. Establish point/plot center in unit.
2. Check all trees that are within the unit, with an angle gauge or Relaskop, and record all In trees.
3. Measure the shortest horizontal distance from point/plot center to the unit boundary. The unit boundary is defined as a straight line between boundary tags.
4. On this same line, measure an equal horizontal distance outside the unit boundary.
5. Establish a Mirage point/plot center at that distance.
6. Recheck only the original In trees from the Mirage/plot center. Record again, the original trees that are In from the Mirage point/plot center.

## Original Point/Plot



- Original point/plot contains five "In" trees.


## Mirage Method for Boundary Overlap on Points



- Mirage plot contains tree numbers 1 and 5 from the original plot and would be double tallied.


## R6 FScruiser TREE CARD



## Notes:

## Insert Divider Page Here

## Glossary

Accuracy: Refers to how well the sample estimates the true value of a quantity. An estimate may be very precise, but because of bias, may still be inaccurate.

Area Based Cruise: Volumes are determined, based on volume per acre and expanded by the number of acres in the unit; i.e. Fixed Plot, Point Sampling.

Backsight: A sight or bearing, taken with a compass, from a point or station to the previous station.
Bark: All the tissues, including the cambium, taken collectively and forming the exterior covering of the xylem of a tree.

Basal Area (BA): The square foot area of a tree based on its DBH.
Basal Area Factor (BAF): Each sample tree, regardless of its actual diameter, represents a constant basal area per acre. This constant is called the basal area factor of the critical angle, i.e., if using a 20 BAF each "IN" tree represents 20 square feet of basal area per acre.

Bias: A systematic error.
BdFt (BF, Board foot): A unit of measure with dimensions of 1" x 12" x 12".
Bole: A tree stem that has grown to substantial thickness, generally capable of yielding saw timber, veneer logs, large poles, or pulpwood.

Bolt: Any short $\log$ cut to a specific length.
Breakage: Includes all falling, bucking, yarding, loading and all other damage.
Butt End: The end of a tree length originally connected to the stump.
Butt Log: The lowest log on a tree bole.
Butt Rot: Any decay or rot developing in and sometimes characteristically confined to the base or lower stem of a tree.

Butt Swell: That part of a log outside its normal taper, extending from where the normal taper ends and the flare begins to the large end of the log. Swelling can be an indicator of butt rot.

Catface: A defect on the surface of a tree or log, resulting from a wound where healing has not reestablished the normal cross section.

CCF: A hundred cubic feet.
CuFt (CF, Cubic foot): A unit of measure with dimensions of 12 " $\times 12$ " $\times 12$ ".

Char: Results from heat causing change in the general chemical composition of the wood.
Charred Wood: Wood converted to charcoal as a result of incomplete combustion.
Check, Heart: A check or separation originating at the pith and extending across the annual rings.
Check, Weather: A check or separation originating on the surface and penetrating into the sapwood and in some cases into the heartwood.

Conk: The fruiting body of a fungus denoting the presence of rot. The conk may be of various shapes and sizes.

Contour Lines: A contour line is an imaginary level line on the ground connecting all points of equal elevation.

Count Tree: A tree that will be counted or tallied and not measured.

Crook: An abrupt curve or bend and is normally confined to a short portion of a log.
Cross Grain: material with grain deviation that exceeds 3 inches per foot from straight.
Cruising: Determining the volume and/or value of trees as they stand.
Cull Log: A log not meeting the specified product requirements due to defect.
DBH: Diameter Breast Height, measured at 4.5 feet above the natural forest floor on the high side of the tree.

Debarkability: A log segment shall be considered debarkable if it would not create a safety hazard, would not fall apart when subjected to the mechanical debarking process, and is $90 \%$ debarkable.

Decay: The decomposition of wood substance caused by the action of wood-destroying fungi, resulting in softening, loss of strength and mass, and often in change of texture and color. Examples of decay are: heart rot, sap rot, stump rot and rotten knots.

Declination: Magnetic declination is the angular difference between true north and magnetic north. This can vary by forest. Commonly between 17 and 21 degrees East.

Defect: Any unsound wood or abnormal shape of a log affecting the quantity of products for which the $\log$ is being assessed.

Diameter, Small End: The average diameter, inside bark, at the upper end of the tree length or log segment.

Diameter Tape: A circumference tape measure specially graduated so the diameter may be read directly when the tape is placed around a tree stem, bole, or piece of roundwood.

DIB: Diameter Inside Bark, a measurement of the diameter at a point on a tree or log that includes the wood only.

DOB: Diameter Outside Bark, a measurement of the diameter at a point on a tree or log that includes the wood and bark.

Estimate: A prediction of tree volume or value based on local volume or value tables.
Expansion Factor: In any sampling scheme, only selected trees are measured. These measure trees represent those that were not measured. Factors are developed and used to expand this sample tree volume to calculate the total sale volume.

Fiber: Sound wood content of a log that is not related to a specific product.
Fire Scar: A healing or healed-over injury on a woody plant caused or aggravated by fire.
Firm Red Heart Rot: A form of incipient decay characterized by a reddish color produced in the heartwood, which does not render the wood unfit for the majority of uses. Firm red heart rot contains none of the white pockets characterizing the more advanced stage of decay.

Flare: A rapid increase in the taper of a $\log$ at the butt end due to swell. See "Butt Swell".
Flewelling Westside Equations: Stem profile equation originating in Western Oregon and Washington. Similar to INGY equations.

Flutes: A rounded groove or channel in the exterior of the tree bole.
Foresight: A sight or bearing, taken with a compass, from a point or station to establish the next station.
Fork: A division of a log or stem of a tree into two or more prongs.
Form Class: The ratio of the diameter inside bark at the top of the first log to the diameter at breast height.

Frequency: A term denoting sampling intensity, i.e., 1:100, meaning that on an average one tree out of one hundred will be selected for sampling.

Frost Crack(s): Cracks that occur when extremely low temperatures freeze and expand the moisture in trees.

Gross Volume: Total volume including defects.
Heart Rot: Any rot characteristically confined to the heartwood. It generally originates in the living tree.

Heartwood: The inner core of a woody stem wholly composed of nonliving cells and usually differentiated from the outer enveloping layer (sapwood) by its darker color.

Hidden Defect: Defect within the inner portion of the tree having no visible indicators, therefore, the cruiser can make no deductions.

Incipient Decay: The early stage of decay in which the decomposition has not proceeded far enough to soften or otherwise change the hardness of the wood perceptibly. It is usually accompanied by a slight discoloration of the wood. (See "Firm Red Heart Rot".)

INGY: Inland Growth and Yield study used to develop Stem Profile volume equations.
"In" Tree: A tree that has been selected as a "count" or "measure" tree on a Fixed Plot or Point Sample.

Intermediate Decay: A more advanced stage of decay than incipient decay, characterized by a change in the color of the wood and some slight decomposition and loss of strength which does not render the wood unfit for general purpose. See "White Speck".
$\mathbf{K}$ : The largest number in the random number list.
KPI: An estimated volume or value of a tree.
KZ: The sampling rate and is equal to the estimated volume divided by the number of samples.
Knot: A portion of a branch enclosed in the xylem by the natural growth of the tree.
Limiting Distance: The maximum distance a tree can be from the point/plot center and still be IN, a sample tree.

Log: A section of the bole of a felled tree, after bucking.
Log Height: Height of a tree measured from a stump height to a specified top or contract minimum top diameter and recorded to the nearest one-half log.

MBF: One thousand board feet.
Massed Pitch: wood impregnated with pitch, usually associated with the lower portion of the tree.
Measure (Sample) Tree: An individual tree included in a sample for the purpose of measurement.
Mean: The average value obtained from dividing the sum of sample values by the number of samples.
Merchantable Height in Feet: Height of a tree measured from a stump height to a specified top or contract minimum top diameter and recorded to the nearest foot.

Net Volume: The volume remaining after all deductions for defects from gross volume has been made.

Non-Sawlog: Shall be suitable for the production of any product other than lumber or veneer.
"Out" Tree: A tree that may be within a Fixed Plot or Point Sample, but has not been selected for a "count" or "measure" tree.

Perimeter Defect: Defect originating in the outer diameter or surface of the log. Examples would be saprot, weather checks and char.

Piece: A part of a whole (as of a tree); it also means an object regarded as a unit of a kind (as one of a number of products of the group).

Plot(s): Small fixed area(s) that trees are measured on. The resulting data is expanded to determine total sale volume.

Plot Size: An area expressed as a fraction of an acre (1/10, 1/20).
Pocket Rot: In wood, any rot localized in small areas, generally forming round or lens-shaped cavities.
Point(s): An established spot where IN trees are determined by using a specified Basal Area Factor.
Precision: The extent of clustering of sample values about their mean.
Primary Product: A product that comes from a tree or log that could produce lumber, veneer or any other commodity.

Product: A commodity manufactured from a portion of a tree.
Product Estimator: A procedure, equation, or table used to estimate the product volume of a tree or tree segment. Potential sawn lumber measured in board feet is the most common product estimated. Product estimators are frequently misclassified as volume estimators.

Product Volume: A statement of the potential amount of a manufactured product; board feet, cubic feet, square feet, lineal feet and so forth.

Pulp: A fibrous basic product used in the development of items manufactured from wood chips.
Pulp Chips: Particles of wood cut diagonally from logs or large pieces of wood, generally about $3 / 4$ inches in length and used for making pulp.

Pulpwood: Wood cut and prepared primarily for manufacture into wood pulp.
Reference Diameter: The specified bole diameter to which height is measured.

Reference Height: The height measured to a specified point on the tree bole.
Ring Rot: Any rot localized mainly in the early wood of the annual rings, giving a concentric pattern of decaying wood in cross-section.

Ring, Pitch: A separation of the annual rings accompanied with pitch, and partially or completely encircles the pith.

Ring, Shake: A separation of the annual rings, unaccompanied with pitch, and partially or completely encircles the pith.

Rot: The decomposition of wood substance caused by the action of wood-destroying fungi, resulting in softening, loss of strength and mass, and often in change of texture and color.

Round wood: Any section of the stem or of the thicker branches of a tree of commercial value that has been felled or cut but has not been processed beyond removing the limbs, or bark, or both.

Sample: A subset of a population, being representative of that population.
Sample Size: The number of sampling units included in a sample.
Sample (Measure) Tree: An individual tree included in a sample for the purpose of measurement.
Sample Group: One of the units, groups or strata into which a population is subdivided for purposes of sampling.

Sap Rot: Any rot characteristically confined to the sapwood.
Sapwood: The living wood of pale color near the outside of the log.
Sawlog: Shall be suitable for the production of lumber or veneer to an amount of not less than 40 percent of the Gross Cubic Foot Volume or $33.3 \%$ (34\%) of the Gross Scribner Volume.

Scaling (verb): To measure or estimate the quantity, expressed as the volume, or area, or length, or mass, or number of products obtained from trees after they are felled. See National Forest Log Scaling Handbook, FSH 2409.11 and FSH 2409.11a for scaling practices and procedures.

Scaling Cylinder: an imaginary cylinder extending through the log or segment with a diameter equal to the small end diameter.

Scribner Decimal C Rule: a standard rule approved for measurement of Forest Service timber. This rule rounds contents to the nearest 10 board feet.

Secondary Product: A tree or log that will produce products other than lumber or veneer.
Severe Crook: A sharp bend in a $\log$ that results in a portion of it being unusable. This defect may render a $\log$ cull if severe enough to make it non debarkable. See "Debarkability".

Shake: A separation along the grain and occurring between or across the annual rings, but not extending from one surface to another.

Shatter: Breakage, usually found on wind sheared or broken off trees, that run laterally along a log and can affect a portion of or the entire length of the log, making it non debarkable. See "Debarkability".

Smalian Cubic Foot Log Rule: a standard rule approved for the measurement of Forest Service timber. This rule determines volume in cubic feet.

Smalian Formula: Cubic log volume determination formula: Volume $=0.002727\left(D^{2}+d^{2}\right) L$

Soft Rot: A soft, weak, often spongy wood condition caused by decay.
Sound wood: Wood free from structural defect.
Stem: The principle axis of a plant from which buds and shoots develop. Larger tree stems are called boles.

Stem Profile Equation: A mathematical representation of a tree's profile or shape used for volume determination.

Subpopulation Code: A code used in combination with a sample group and species to define a sample population with similar characteristics including the default Form Class and grade. This reduces the amount of information entered at tree data screens. This code populates redundant information needed on every tree record.

Sweep: A gradual curve in a tree that may affect the entire tree or a portion of that tree.
Taper, Log: The progressive change in the diameter of a $\log$ from one end, or point on its length, to another.

Taper, Tree: The progressive decrease in the stem or bole diameter of a tree from the ground or a specified point on the lower bole to the tip or specified point on the upper bole.

Top DIB: Top Diameter Inside Bark. A measurement of the diameter at a point on a tree, which includes the wood only.

Total Tree Height: Height of a tree measured from stump height to the tip of the leader and recorded to the nearest foot.

Traverse: Entails taking bearings or azimuths, slope, and distance of lines enclosing an area, such as a timber sale unit.

Tree Based Cruise: A cruise method where volumes are calculated or expanded based on individual tree volumes (STR, 3P).

Tree Volume, Merchantable: The portion of tree volume that can be sold and utilized in a manufacturing process.

Tree Volume, Total: The content of a tree from ground to tip. This might or might not include the content of limbs.

Variable of Interest: The variable on which the CV is based. This variable is unique by cruise method.

Variance: A measure of how the sample unit values, such as tree volumes, are disbursed (clustered, scattered) around the mean (average).

VBAR: Volume to Basal Area Ratio.
Visible Defect: Defect that is proven by the existence of visible indicators.
Void: Wood fiber absent from a log or part of a log that otherwise would usually be regarded as naturally complete. It may be caused by advance decay, fire, or the operation of a machine or tool.

Volume Equations: Formulas used to determine individual tree volumes.
Volume Estimator: An equation or series of equations used to estimate the average volume of a log or tree.

White Speck: Small white pits or streaks in the wood, characteristic of the intermediate stage of Phellinus pini (Fomes pini) decay.

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## Workbook Class Problem Answers

## Abnormal Diameters

Class Problems
No. 1
Instructions: Draw location of measure point(s).
Make notes to help describe measurements.
a.) Measure as one tree and record. May have to adjust for excessive flair or taper.
b.) Measure as two trees.
c.) Measure above and below the abnormality and average.
d.) Measure above the swell and adjust for taper to approximate DBH.
e.) Measure as close to DBH as possible and adjust for taper or measure above and below break and average.
f.) Measure directly.
g.) Measure as close to DBH as possible and adjust for taper. Measure as two trees.


## Height Measurements

1. Region 6 currently utilizes three tree height measurement types. What are they? Describe briefly.
a. Total Tree Height - measurements are taken from stump height to tip of the leader and recorded in feet.
b. Merchantable Height in Feet - measurements are taken from stump height to a specified top or contract minimum diameter and recorded in feet.
c. Log Height - measurements are taken from stump height top specified top or contract minimum diameter and recorded to nearest one-half log. Minimum is one log.
2. What are the heights of the leaning trees?
a. $A C=\sqrt{A B^{2}+B C^{2}}=\sqrt{150^{2}+40^{2}}=155.2^{\prime}=155^{\prime}$
b. $A C=\sqrt{A B^{2}+B C^{2}}=\sqrt{112^{2}+30^{2}}=115.9=116^{\prime}$


## Slope Adjustment

Class Problem
No. 3
Instructions: Calculate tape slope distance from the tree.

| Desired Horizontal <br> Distance | Percent Slope <br> From Tree | Taped Distance |
| :---: | :---: | :---: |
| $66^{\prime}$ | $+34 \%$ | $66 * 1.057=69.762=69.76^{\prime}$ |
| $100^{\prime}$ | $+15 \%$ | $100 * 1.01=101^{\prime}$ |
| $66^{\prime}$ | $+65 \%$ | $66 * 1.194=78.804=78.80$ |
| $99^{\prime}$ | $-35 \%$ | $99 * 1.06=104.94$ |
| $33^{\prime}$ | $+40 \%$ | $33 * 1.077=35.541=35.54$ |


| Slope Adjustment Factors in One Percent Increments |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \text { \% } \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \text { \% } \\ \text { Slope } \end{gathered}$ | Adjustment Factor | \% Slope | Adjustment Factor | \% Slope | Adjustment Factor | \% Slope | Adjustment Factor |
| 5 | 1 | 29 | 1.041 | 53 | 1.132 | 77 | 1.262 | 101 | 1.421 |
| 6 | 1.001 | 30 | 1.044 | 54 | 1.136 | 78 | 1.269 | 102 | 1.428 |
| 7 | 1.002 | 31 | 1.047 | 55 | 1.141 | 79 | 1.275 | 103 | 1.436 |
| 8 | 1.003 | 32 | 1.05 | 56 | 1.146 | 80 | 1.281 | 104 | 1.443 |
| 9 | 1.004 | 33 | 1.054 | 57 | 1.151 | 81 | 1.287 | 105 | 1.45 |
| 10 | 1.005 | 34 | 1.057 | 58 | 1.156 | 82 | 1.293 | 106 | 1.457 |
| 11 | 1.006 | 35 | 1.06 | 59 | 1.161 | 83 | 1.3 | 107 | 1.464 |
| 12 | 1.007 | 36 | 1.063 | 60 | 1.166 | 84 | 1.306 | 108 | 1.472 |
| 13 | 1.008 | 37 | 1.067 | 61 | 1.172 | 85 | 1.312 | 109 | 1.479 |
| 14 | 1.009 | 38 | 1.07 | 62 | 1.177 | 86 | 1.319 | 110 | 1.486 |
| 15 | 1.01 | 39 | 1.074 | 63 | 1.183 | 87 | 1.325 | 111 | 1.494 |
| 16 | 1.012 | 40 | 1.077 | 64 | 1.188 | 88 | 1.332 | 112 | 1.501 |
| 17 | 1.014 | 41 | 1.081 | 65 | 1.194 | 89 | 1.338 | 113 | 1.509 |
| 18 | 1.016 | 42 | 1.085 | 66 | 1.199 | 90 | 1.345 | 114 | 1.516 |
| 19 | 1.018 | 43 | 1.089 | 67 | 1.205 | 91 | 1.352 | 115 | 1.524 |
| 20 | 1.02 | 44 | 1.093 | 68 | 1.21 | 92 | 1.359 | 116 | 1.532 |
| 21 | 1.022 | 45 | 1.097 | 69 | 1.216 | 93 | 1.365 | 117 | 1.539 |
| 22 | 1.024 | 46 | 1.101 | 70 | 1.221 | 94 | 1.372 | 118 | 1.547 |
| 23 | 1.026 | 47 | 1.105 | 71 | 1.227 | 95 | 1.379 | 119 | 1.554 |
| 24 | 1.028 | 48 | 1.11 | 72 | 1.233 | 96 | 1.386 | 120 | 1.562 |
| 25 | 1.031 | 49 | 1.114 | 73 | 1.238 | 97 | 1.393 |  |  |
| 26 | 1.034 | 50 | 1.118 | 74 | 1.244 | 98 | 1.4 |  |  |
| 27 | 1.036 | 51 | 1.123 | 75 | 1.25 | 99 | 1.407 |  |  |
| 28 | 1.039 | 52 | 1.127 | 76 | 1.256 | 100 | 1.414 |  |  |

Distance Correction: Horizontal distance $*$ slope adjustment factor $=$ adjusted slope distance .

## Height Measurement

Instructions: Calculate height using the percent scale.

| Horizontal Distance From Tree 85' | Measured Height 92' | Actual Height $.85 * 92=78.2=78$ |
| :---: | :---: | :---: |
| 105 | 110 | $1.05 * 110=115.5=116$ ' |
| 100 | 113 ' | $1.00 * 113=113$ ' |
| 75 | 102' | . $75 * 102=76.5=77$ |
| $125{ }^{\prime}$ | 85' | $1.25 * 85=106.25=106$ |

Instructions: Calculate height using the topographic scale

| Horizontal Distance <br> From Tree <br> $99^{\prime}$ | Measured <br> Height | Actual Height |
| :---: | :---: | :--- |
| $69^{\prime}$ | $51^{\prime}$ | $64 * 1.5=96^{\prime}$ |
| $132^{\prime}$ | $65^{\prime}$ | $\frac{51 * 1.0=51^{\prime}}{65 * 2.0=130^{\prime}}$ |
| $33^{\prime}$ | $64^{\prime}$ | $\frac{64 * 0.5=32^{\prime}}{}$ |
| $66^{\prime}$ | $62^{\prime}$ | $\boxed{62 * 1.0=62^{\prime}}$ |

## Relaskop Diameters

Instructions: Determine bar width equivalents.

| Horizontal Distance <br> From Tree <br> $99^{\prime}$ | Single <br> Small Bars <br> $6^{\prime \prime}$ | $2 "$ |
| :---: | :---: | :---: |
| $33^{\prime}$ | $8^{\prime \prime}$ | Pair of <br> Large bars <br> $3 "^{\prime \prime}$ |
| $132^{\prime}$ | $4 "$ | $12^{\prime \prime}$ |
| $66^{\prime}$ | - | $48^{\prime \prime}$ |
|  |  |  |

9. What bars would you use to measure a $38^{\prime \prime}$ diameter at $33^{\prime}$ and $66^{\prime}$ ?
a. Use two pair of large bars ( $24 "$ ) and two small bars $(4 ")=28 "$
b. Use one pair of large bars (24") and one small bar (4") $=28^{\prime \prime}$

## Relaskop Heights

Class Problem
No. 6

Instructions: Calculate Heights.

| Top <br> Measurement | Stump <br> Measurement | Height <br> $+92^{\prime}$ |
| :---: | :---: | :---: |
| $+67^{\prime}$ | $-5^{\prime}$ | $92-(-5)=97^{\prime}$ |
| $+25^{\prime}$ | $-32^{\prime}$ | $\frac{67-(+6)=61}{}$ |
| $+67^{\prime}$ | 0 | $25-(-32)=57^{\prime}$ |
| $+75^{\prime}$ | $-6^{\prime}$ | $67-(0)=67^{\prime}$ |
|  |  | $75-(-6)=81^{\prime}$ |

## Form Class

Class Problem

Instructions: Calculate Form Class
5. DBH: $26.5 "$

DOB: 14.0"
BTR: . 90
FC: $\quad 48$

$$
\frac{D O B * B T R}{D B H} * 100=\frac{14.0 " * .90}{26.5 "} * 100=47.547=48
$$

6. DBH: 32.0 "

DIB: 24.0"
BTR: . 80
FC: 75

$$
\frac{D I B}{D B H} * 100=\frac{24.0^{\prime \prime}}{32.0^{\prime \prime}} * 100=75
$$

7. DBH: 18.5 "

DOB: 15.0"
BTR: . 92
FC: $\quad 75$

$$
\frac{D O B * B T R}{D B H} * 100=\frac{15.0^{"} * .92}{18.5^{\prime \prime}} * 100=74.59=75
$$

8. DBH: $12.3 "$

DIB: 9.9"
BTR: . 96
FC: $\quad 80$

$$
\frac{D I B}{D B H} * 100=\frac{9.9^{\prime \prime}}{12.3^{\prime \prime}} * 100=80.487=80
$$

## Species Identification

1. What are four characteristics or factors in helping to determine species identification?
a. Bark color, pattern, and texture
b. Tree form or shape
c. Number of needles
d. Length and shape of needles
e. Cone size and shape
f. Geographic location

## Product Designation

## "Grades"

Class Problem
No. 9

1. Surface characteristics are a factor in product designation grades. T F
2. Assume a sawlog (Grade 1) until ruled out.
3. Serious defect could affect product designation.
4. Why is it necessary to determine the location of each log segment? To properly assign grade and defect to correct segment.

## Defect

## Class Problem

No. 10

1. What are the two primary causes of visible defect?
a. Natural Defects
b. Logging/Mechanical Defects
2. Defect deductions can be made if you just know there is defect, but there are no visible indicators.

$$
\mathrm{T} \quad \underline{\mathbf{F}}
$$

3. What are the three areas of the tree affected by rot?
a. Root and Butt
b. Heartwood and Stem
c. Sapwood or Perimeter
4. Name five types of defect a cruiser should deduct for in a sawlog (Grade 1).
a. Breaks Fire Scars
Soft Rots
b. Checks
Frost Cracks Char
c. Rots
Lightening Scars
Massed Pitch
d. Crooks
Metal Objects
e. Sweep
Voids
5. Name six visible defect indicators.
a. Butt Swell

Broken Tops
b. Sap Rot Sucker Limbs
c. Conks Fire Scars
d. Crook

Insect Damage
e. Bark Seams

## f. Cat Faces

7. When non-sawlog products are included in the cruise, when can a non-sawlog become a cull (Grade 9).
a. Never, Grad 9 is inapplicable when non-sawlog products are included in the cruise.

## Sample Tree

Class Problem
No. 11

1. List two methods of minimizing bias in selecting cruise trees when Sample Tree cruising.
a. Only mark and call out one tree at a time
b. Use a random number list or a data recorder controlled by a tally person to select cruise trees.
2. Each tree to be harvested must be counted.

$$
\underline{\mathbf{T}} \quad \mathrm{F}
$$

3. If your sale had a lot of variability in the tree-to-tree net volumes, fewer samples would be required.

$$
\mathrm{T} \quad \underline{\mathbf{F}}
$$

4. Equal probability is the same as each tree having an equal chance of being selected for measure.

5. Describe how a Sample Tree cruising system operates.
6. Tree is marked for cutting.
7. Tree is called out to the tally person and compared to a random number to determine if measured.
8. Tree is counted.
9. If tree is a sample tree, it is cruised and monumented for check cruising. Follow monumentation directions described in the cruise plan.

No. 12

1. The cruiser estimates__ diameter_and/or__ height of each tree to be harvested. A table is used to convert these estimates to volume. The estimated volume is called a_KPI .
2. Larger trees have a better chance of being selected as cruise trees than small trees.

3. In 3 P cruising, units must be traversed to get accurate acreages for computing timber sale volume.
T $\quad \underline{F}$
4. The cruiser should know the next random number before the volume is estimated.
T
F

## Fixed Plot

Class Problem

No. 13

1. What are the acceptable shapes of plots?
a. Circular (most common).
b. Rectangular .
c. Square .
2. Are all plots in a unit the same size?

$$
\underline{\text { Yes }} \quad \text { No }
$$

3. Cruiser determines volume per plot.

$$
\underline{\mathbf{T}} \quad \mathrm{F}
$$

4. Both the acreage harvested and the total number of trees must be known to determine volume in the timber sale.

$$
\begin{array}{ll}
\mathrm{T} & \underline{\mathbf{F}}
\end{array}
$$

5. The plot boundary location is estimated.

$$
\begin{array}{ll}
\mathrm{T} & \underline{\mathbf{F}}
\end{array}
$$

6. It is not necessary to compensate for slope when cruising fixed plots.

$$
\begin{array}{ll}
\mathrm{T} & \underline{\mathbf{F}}
\end{array}
$$

7. Every merchantable tree within the plot must be numbered to assist check cruising.

$$
\underline{\mathbf{T}} \quad \mathrm{F}
$$

8. If the plot boundary passes through the center of the tree at stump height, it is considered In.

$$
\begin{array}{ll}
\mathrm{T} & \underline{\mathbf{F}}
\end{array}
$$

# Limiting Distance for Fixed Plot 

Class Problem
No. 14
The Horizontal Plot Radius for a $1 / 10^{\text {th }}$ acre Circular Fixed Plot is 37.24 feet.
[PR-(DBH/24)] * Slope Adjustment Factor = Slope Limiting Distance


| Slope Adjustment Factors in One Percent Increments |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \hline \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor | $\begin{gathered} \% \\ \text { Slope } \end{gathered}$ | Adjustment Factor |
| 5 | 1 | 29 | 1.041 | 53 | 1.132 | 77 | 1.262 | 101 | 1.421 |
| 6 | 1.001 | 30 | 1.044 | 54 | 1.136 | 78 | 1.269 | 102 | 1.428 |
| 7 | 1.002 | 31 | 1.047 | 55 | 1.141 | 79 | 1.275 | 103 | 1.436 |
| 8 | 1.003 | 32 | 1.05 | 56 | 1.146 | 80 | 1.281 | 104 | 1.443 |
| 9 | 1.004 | 33 | 1.054 | 57 | 1.151 | 81 | 1.287 | 105 | 1.45 |
| 10 | 1.005 | 34 | 1.057 | 58 | 1.156 | 82 | 1.293 | 106 | 1.457 |
| 11 | 1.006 | 35 | 1.06 | 59 | 1.161 | 83 | 1.3 | 107 | 1.464 |
| 12 | 1.007 | 36 | 1.063 | 60 | 1.166 | 84 | 1.306 | 108 | 1.472 |
| 13 | 1.008 | 37 | 1.067 | 61 | 1.172 | 85 | 1.312 | 109 | 1.479 |
| 14 | 1.009 | 38 | 1.07 | 62 | 1.177 | 86 | 1.319 | 110 | 1.486 |
| 15 | 1.01 | 39 | 1.074 | 63 | 1.183 | 87 | 1.325 | 111 | 1.494 |
| 16 | 1.012 | 40 | 1.077 | 64 | 1.188 | 88 | 1.332 | 112 | 1.501 |
| 17 | 1.014 | 41 | 1.081 | 65 | 1.194 | 89 | 1.338 | 113 | 1.509 |
| 18 | 1.016 | 42 | 1.085 | 66 | 1.199 | 90 | 1.345 | 114 | 1.516 |
| 19 | 1.018 | 43 | 1.089 | 67 | 1.205 | 91 | 1.352 | 115 | 1.524 |
| 20 | 1.02 | 44 | 1.093 | 68 | 1.21 | 92 | 1.359 | 116 | 1.532 |
| 21 | 1.022 | 45 | 1.097 | 69 | 1.216 | 93 | 1.365 | 117 | 1.539 |
| 22 | 1.024 | 46 | 1.101 | 70 | 1.221 | 94 | 1.372 | 118 | 1.547 |
| 23 | 1.026 | 47 | 1.105 | 71 | 1.227 | 95 | 1.379 | 119 | 1.554 |
| 24 | 1.028 | 48 | 1.11 | 72 | 1.233 | 96 | 1.386 | 120 | 1.562 |
| 25 | 1.031 | 49 | 1.114 | 73 | 1.238 | 97 | 1.393 |  |  |
| 26 | 1.034 | 50 | 1.118 | 74 | 1.244 | 98 | 1.4 |  |  |
| 27 | 1.036 | 51 | 1.123 | 75 | 1.25 | 99 | 1.407 |  |  |
| 28 | 1.039 | 52 | 1.127 | 76 | 1.256 | 100 | 1.414 |  |  |

## Point Sampling

Class Problem
No. 15

1. Larger trees have a greater chance of being selected as sample trees.

## T F

2. Cruiser does not have to measure plot boundaries when point sampling.

## T F

3. In order to be selected as a sample tree, a tree with a 20 " DBH must be closer to point center when a 10 BAF is used than when a 40 BAF is used.

## T $\quad \mathbf{F}$

4. It is not necessary to measure limiting distance on borderline trees.

T $\quad \underline{F}$
5. Point sampling determines volume per acre.

## T $\quad \mathrm{F}$

6. No trees are measured on count points.

$$
\underline{\mathbf{T}} \quad \mathrm{F}
$$

7. What does BAF stand for? Basal Area Factor
8. Is this tree In or Out using a 10 BAF:

Tree is In.

2. What is the Horizontal Limiting Distance of these trees to the face of the tree?

| DBH | BAF | Limiting Distance |
| :--- | :---: | :--- |
| 23.4 | 10 | $\underline{23.4 * 2.708=63.3673=63.37}$ |
| 10.8 | 20 | $\underline{10.8 * 1.902=20.5416=20.54^{\prime}}$ |
| 18.6 | 5 | $\underline{18.6 * 3.847=71.5542=71.55^{\prime}}$ |
| 12.3 | 40 |  |

Plot radius factor to face of tree:

| BAF | PRF |
| :---: | :--- |
| 5 | 3.847 |
| 10 | 2.708 |
| 20 | 1.902 |
| 40 | 1.333 |

3. What is the slope limiting distance of the tree shown below?
$D B H * P R F *$ SlopeAdjustmentFactor $=17.2 * 1.902 * 1.097=35.8877=35.89^{\prime}$
or

DBH $*$ Adjusted $P R F=17.2 * 2.0865=35.8878=35.89^{\prime}$

Is the tree In or Out? $\qquad$ .

20 BAF
PRF $=1.902$
Slope Adjustment Factor $=1.097$
or
Adjusted Plot Radius Factor $=2.0865$

Stake Top


## Limiting Distance for Point Sampling

Class Problem

No. 17

## DBH * Adjusted Plot Radius Factor = Slope Limiting Distance

| Tree <br> No. | BAF | $\begin{gathered} \% \\ \text { Slope } \end{gathered}$ | DBH | * | Adjusted PRF $^{1}$ | Slope Limiting Distance | Measured Slope Distance | In | Out |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 10 | 66 | 16.7 | * | 3.2469 | 54.22 | 54.26' |  | X |
| 2 | 20 | 23 | 62.1 | * | 1.9515 | 121.19 | 121.00' | X |  |
| 3 | 40 | 31 | 24.6 | * | 1.3957 | 34.33 | $34.49^{\prime}$ |  | X |

${ }^{1}$ Complete tables of Adjusted Plot Radius Factors from $0 \%$ to $100 \%$ slope are found in the Tatum Aids.

## Notes:

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## (Back Cover)

