Michigan Department of Natural Resources

www.michigan.gov/dnr

PRODUCT STANDARDS AND CRUISING MANUAL

Forest Resources Division

IC4057 (01/18/2021)

TABLE OF CONTENTS

PRODUCT STANDARDS

Species

Proper identification of species is important. Merchantability specifications and product value depend on identification of species. The volume equations used to calculate the product volumes produce different volumes for different species due to variations in the tree forms between the species.
A list of species and codes is found in Appendix A.

Diameter at Breast Height (DBH)

The diameter of a tree is a key in determining the products within a tree. The first step in determining a tree's products is determining a tree's DBH. Unless one of the following special situations is encountered, measure DBH at 4.5 feet above the ground line, on the uphill side of the tree. When snow is present, it is essential that a measuring stick is used to determine 4.5 feet. Round each measurement down to the last 0.1 inch. For example, a reading of 4.68 inches is read as 4.6 inches. One-inch classes are defined as follows:

1" CLASS	DIAMETER RANGE
4	
5	4.6 - 5.5
6	5.6 - 6.5
7	6.6 - 7.5
8	7.6 - 8.5
9	8.6 - 9.5
10	9.6 - 10.5
11	10.6 - 11.5
12	11.6 - 12.5
13	12.6 - 13.5
14	13.6 - 14.5
15	14.6 - 15.5
16	15.6 - 16.5
17	16.6 - 17.5
18	17.6 - 18.5
19	18.6 - 19.5
20	19.6 - 20.5
21	20.6 - 21.5
22	21.6 - 22.5
23	22.6 - 23.5
24	23.6 - 24.5

When using a D-tape, follow the procedures shown in Figure 1.

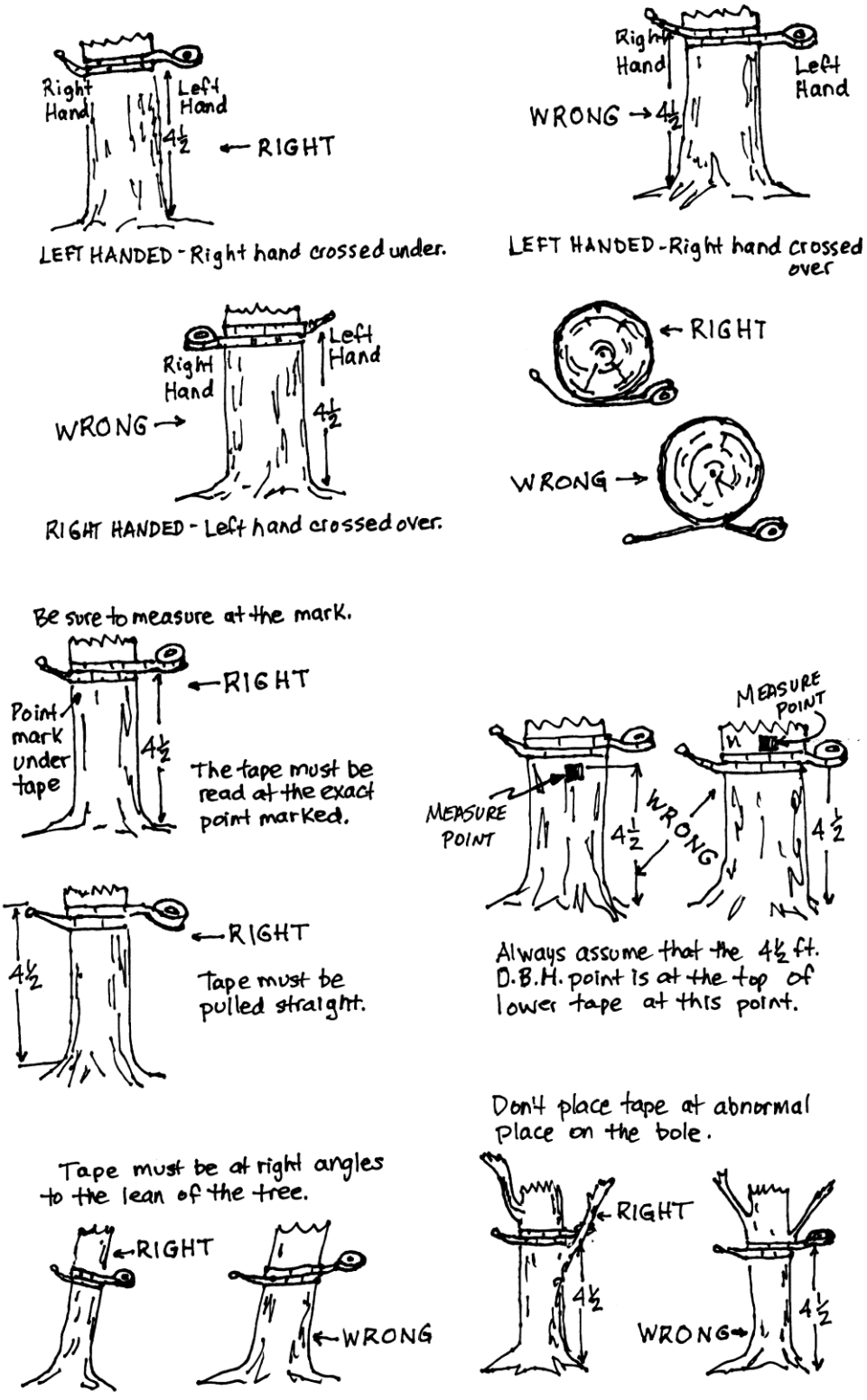


Figure 1 - Proper Technique for Measuring DBH with a D-Tape

Special DBH Situations

1. Forked Tree: A forked tree is a tree with two or more stems originating from one stump. Consider forking to start at the point where daylight is seen.

    a. Trees forked below 4.5 feet: When a tree forks below 4.5 feet, consider as two trees and measure DBH on each stem at 4.5 feet above ground on the high side (Figure 2).

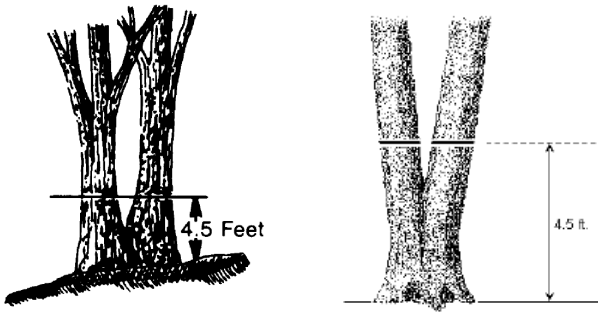


Figure 2 - Fork Occurs Below 4.5 Feet

    b. Trees forked at or above 4.5 feet: When a tree forks at or above 4.5 feet, consider as one tree and record the smallest diameter at 4.5 feet or below (Figure 3).

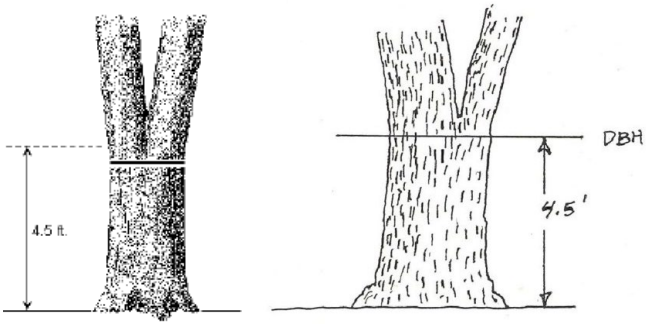


Figure 3 - Fork Occurs Above 4.5 Feet

2. Trees Growing Together: On trees that have grown together, count as two trees. Measure halfway around each, then double each measurement (Figure 4).

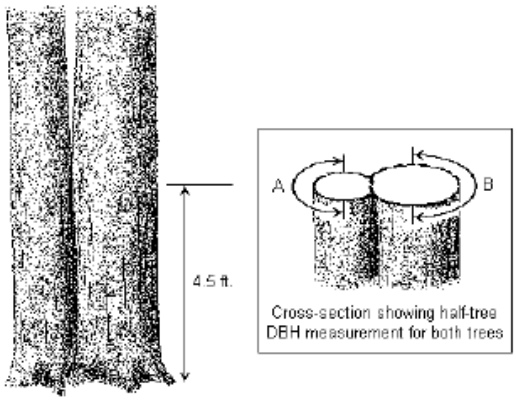


Figure 4 - Measuring DBH on Trees Growing Together

3. Stump Sprouts: Stump sprouts originate between ground level and 4.5 feet on the boles of trees that have died or been cut. Stump sprouts are handled the same as forked trees (Figures 2 – 4).

4. Tree with Irregularities at DBH: On trees with swellings (Figure 5), bumps, depressions, and branches (Figure 6) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

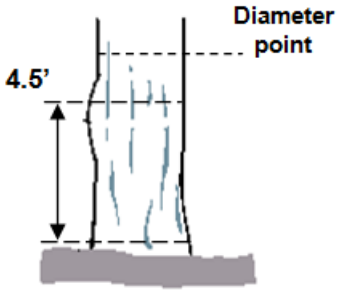


Figure 5 - Tree with Swelling

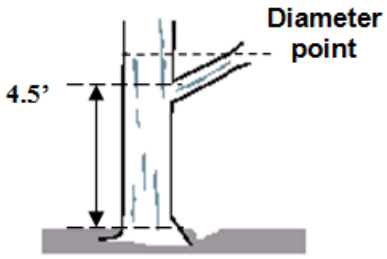


Figure 6 - Tree with Branch

5. Tree on Slope: Measure diameter at 4.5 feet from the ground along the bole on the uphill side of the tree (Figure 7).

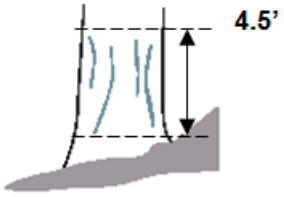


Figure 7 - Tree on a Slope

6. Leaning Tree: M*easure diamete*r at 4.5 feet from the ground along the bole. The 4.5-foot distance is measured along the underside face of the bole (Figure 8).

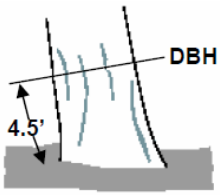


Figure 8 - Leaning Tree

7. Missing Wood or Bark: Do not reconstruct the DBH of a tree that is missing wood or bark at the point of measurement. Record the diameter of the wood and bark that is still attached to the tree (Figure 9). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with irregularities at DBH (Figures 5 and 6).

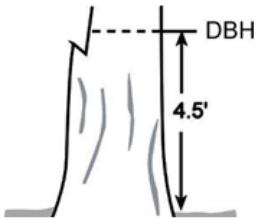


Figure 9 - Tree with Part of Stem Missing

8. Live Windthrown Tree*:* Measure from the top of the root collar along the length to 4.5 feet (Figure 10).

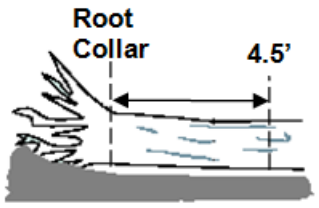


Figure 20 - Tree on the Ground

9. Tree with Curved Bole (Pistol Butt Tree): Measure along the bole on the uphill side (upper surface) of the tree (Figure 11).

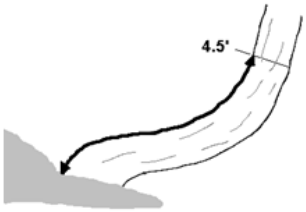


Figure 31 - Tree with Curved Bole (Pistol Butt Tree)

10. Tree Growing on Objects: When trees are growing on objects, such as rocks or logs, measure at 4.5 feet above the root crown rather than above the forest floor. (Figure 12). Trees that reside in water much of the year can also produce "prop-like" roots, measure diameter in a similar method at 4.5 feet above the root crown.

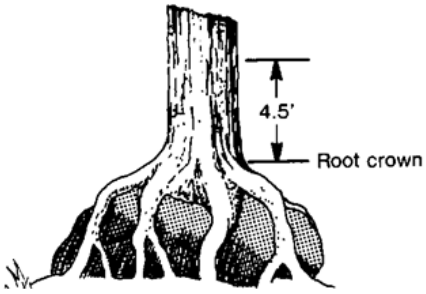


Figure 42 - Trees Growing on Objects (e.g., rocks, logs)

PRODUCTS

Pulpwood

Length and Diameter

A stick of merchantable pulpwood is at least 4.0" in diameter outside the bark (DOB) on the small end and 8.3' or 100" (8' plus 4" extra for leeway) in length. A merchantable tree must contain at least one merchantable pulpwood stick, above the stump. Stump height (**SH**) is measured to the tenth of a foot. Note that stump height is recorded at the cruise level, though a higher or lower stump height can be recorded at the tree level. Height to a 4" Diameter Outside Bark (**H4**), is measured from the ground to the nearest foot. Minimum DBH for a pulpwood tree is 4.6", which is in the 5" diameter class (4.6" – 5.5"). **H4** is recorded on all measure trees, if it exists. If a fork or other defect on the bole of the tree prevents a pulpwood stick from going thru that part of the tree and there are no pulpwood sticks above the fork or defect, then that fork or defect is a pulpwood "stopper". The height to the pulpwood stopper (**HP**) is also recorded (see Stoppers, below). Note

that **H4** must be recorded (if it exists) on measured trees, even if **HP** is also recorded. Deduction lengths are recorded if there is unmerchantable material in the middle of the tree (see Deductions from Useable Height, below).

Note: We sell pulpwood in standard cords, which are defined as a pile of wood 8 feet long by 4 feet high by 4 feet wide. But our taper model calculates volume in cubic feet. There is no precise conversion between a pile of wood that contains air and bark and cubic feet of wood, therefor we use a simple conversion of 79 cubic feet per cord.

Stoppers

Stoppers are defects that end merchantability. Limbs are not generally stoppers for pulpwood (Figure 13). Stopper height is recorded as **HP** (height to pulpwood stopper). **HP** is only recorded if a stopper is present before **H4**.

1. 4.0” DOB
2. Dead tops
3. Excessive branching
4. Section of severe crook

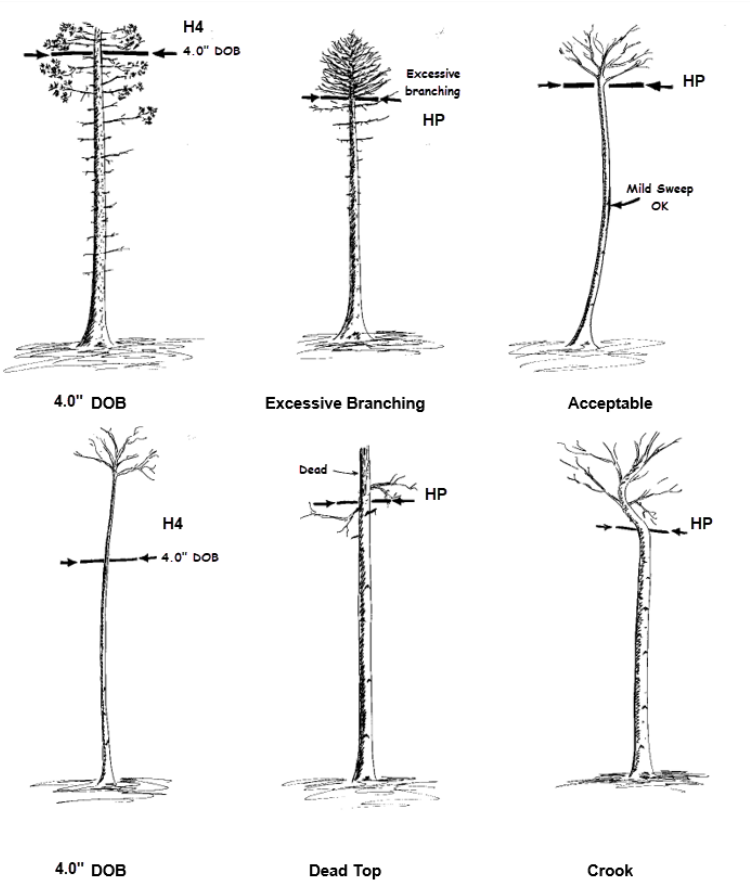
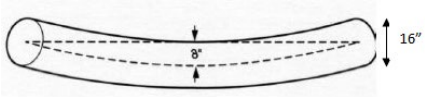


Figure 13 - Stoppers for Pulpwood

Pulpwood Deduction

1. Areas of crook or sweep with merchantable wood above and below this point. Merchantable wood must have one 8’ (100”) useable piece.
    a. Excessive Crook or Sweep
        i. Small pulp: 100” long, <12” on the small end. Too much crook is defined as not being able to fit through a 24” culvert.
        ii. Large pulp: 100” long, >12” on the small end. Maximum 100% sweep or crook of small end DIB.

- Example: A 16” small end DIB could have as much as 16” of sweep before it is considered cull for pulpwood. The following 16” small end DIB has 50% sweep, i.e. 8”:



For Reference

- Verso’s 2011 pulpwood specification – “The entire stick, including sweep and crook, must be no larger than will be able to pass through a straight 30” diameter tube 8’ long with bark attached”.
- Louisiana-Pacific, in Newberry, has a maximum of 6” in a 100” length.

2. Excessive branching.

Sections of the tree that contain bad crook or excessive branching should not be counted as merchantable (Figure 14). Measure these areas of defect to the nearest foot as **DP** (length in Deduct of Pulpwood). Merchantable lengths above or below deduct must be at least 8’ (100”) in length (Figure 15).

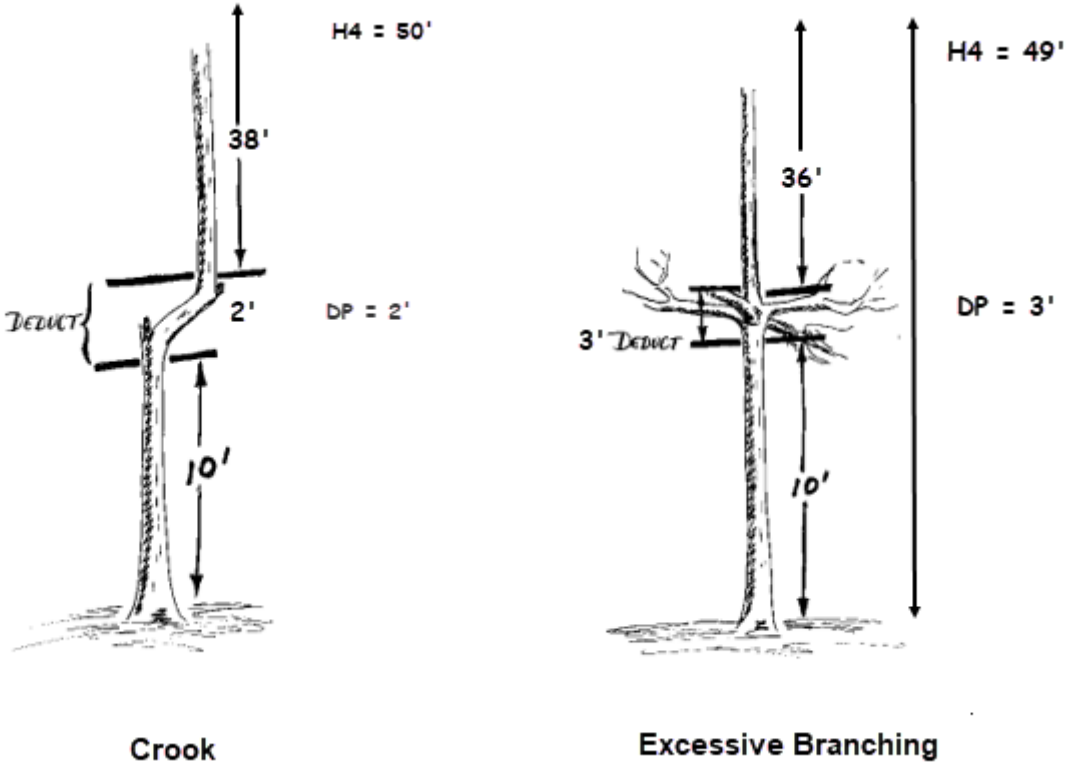


Figure 14 - Deductions from Useable Height for Pulpwood

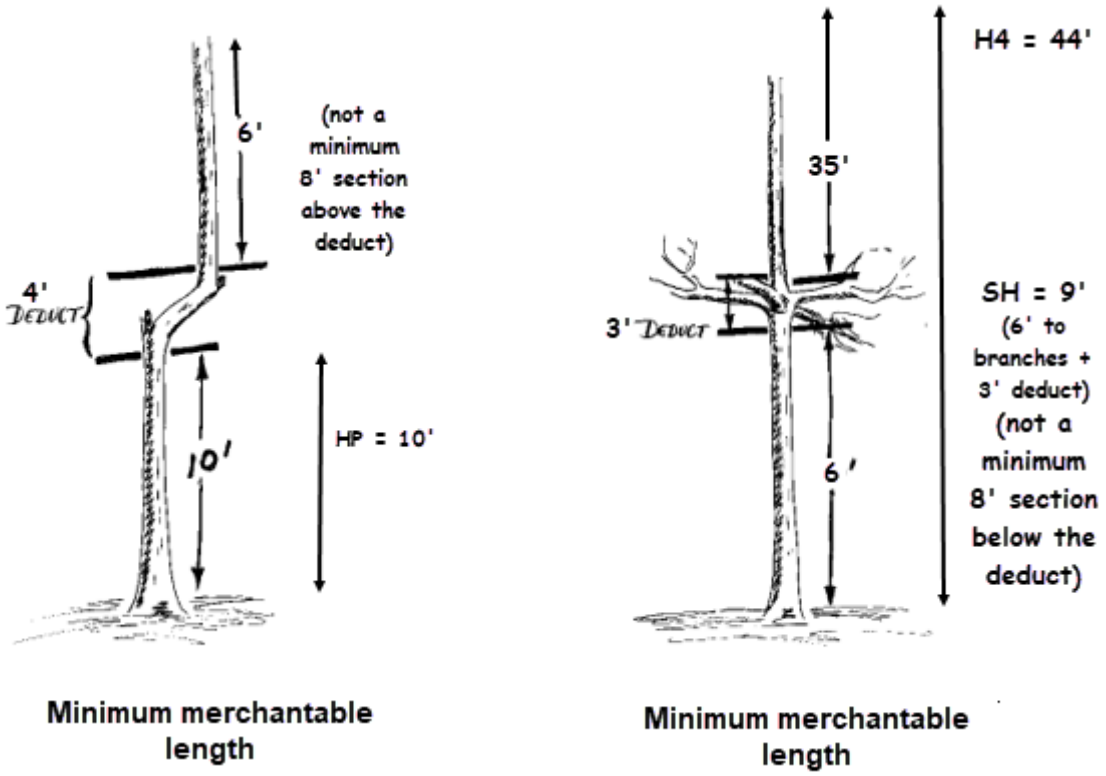


Figure 15 - Deductions and Minimum Merchantable Length for Pulpwood

Deduction Calculations

In the taper model, the volume of deduction for **DP**, **DS** and **LP** is calculated by averaging the volume of the upper portion of the saw (or pulp) length with the lower portion of the saw (or pulp) length. For example, if you recorded a 2' **DS**, the model would calculate the volume for the last 2 feet of the sawlog portion of the tree and the volume of the first 2 feet of the sawlog portion of the tree. The average of the two volumes would be used for the volume of **DS**.

If the deduct is just above the stump, then record a higher stump height rather than using **DP**, **DS** or **LP**. The taper model will calculate the volume from the ground to the height of your stump, rather than averaging a high and low volume. This will provide a better estimate of the deducted volume.

Sawlogs

Length and Diameter

A merchantable sawlog is at least 10.0" in diameter outside the bark (DOB) on the small end and 8.3' or 100" (8' plus 4" extra for leeway) in length and is suitable enough to be cut into boards. A merchantable sawtimber tree must contain at least one merchantable sawlog, above the stump. Stump height (**SH**) is measured to the tenth of a foot. Note that stump height is recorded at the cruise level, though a higher or lower stump height can be recorded at the tree level. Minimum DBH for a sawtimber sized tree is 10.6", which is in the 11" diameter class (10.6" – 11.5"). Sawlog height (**HS**) is not recorded unless obvious stoppers occur below 10.0" DOB. If a fork or other defect on the bole of the tree prevents a sawlog from going thru that part of the tree and there are no sawlogs above the fork or defect, then that fork or defect is a sawlog "stopper". The height to the stopper (**HS**) is then recorded (see Stoppers, below) to the nearest foot, from ground level. Deduction lengths are recorded if there is unmerchantable material in the middle of the sawlog portion of the tree (see Deductions from Useable Height, below).

LOG RULE

Statewide: Scribner Decimal C to a 10.0" top DOB. Minimum DBH is 10.6" which is in the 11" diameter class (10.6" – 11.5"). Note: The taper model calculates all volumes in cubic feet. Board feet cannot be precisely calculated from cubic feet, therefor to get board feet, we use a simple conversion of 185 cubic feet per 1,000 BF.

Things to Look For (Possible Defects)

Sawlogs will have at least 50% of a particular 8' (100") segment in useable wood (i.e., less than 50% deduction for rot, crook, sweep, scars, seams and cracks or a combination of all defects), for any 8' (100") segment. Note that a spiral seam going 360º around the bole would prevent that section of the bole from being considered a sawlog, though it would still be considered pulpwood. If the seam only went 180º, then this seem affects half the log and boards could be cut out of the other half. In this case, it would still be considered a sawlog.

The following is a list of log surface abnormalities that may be considered defects based on severity.

- Bark distortions, bulge, bump, burl, butt scar, bird peck, canker, conk, epicormic branches, holes, knots, metal, rot, seams and wounds.

Log size trees should be looked at closely for these possible defects to determine product potential. Can you cut the log into boards?

Stoppers

Stoppers are defects that end merchantability (Figure 16). Defects that can be cut out are not stoppers if there is at least one 8-foot (100") merchantable sawlog beyond the stopper. Stopper height is recorded as **HS** (height to sawlog stopper). **HS** is only recorded if a stopper is present before the sawlog minimum DOB (10.0").

1. 10.0" DOB (minimum top DOB) - **HS** not recorded if "stopper" is 10.0" DOB
2. Forks before 10.0" minimum DOB
3. Defects (knots, holes, etc.) larger than 1/2 diameter of the tree at that point on the bole
4. Whorls of limbs or sound knots that total greater than 1/2 the diameter of the bole

In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem at an angle of 45 degrees or less. Forks originate at the point of the bole where the piths intersect. A section of the bole with "double pith" is typically a sawlog stopper.

The effect of dead limbs, holes, seams etc., varies greatly from species to species. No standard guidelines can replace knowledge gained locally by observing trees being bucked and sawn.

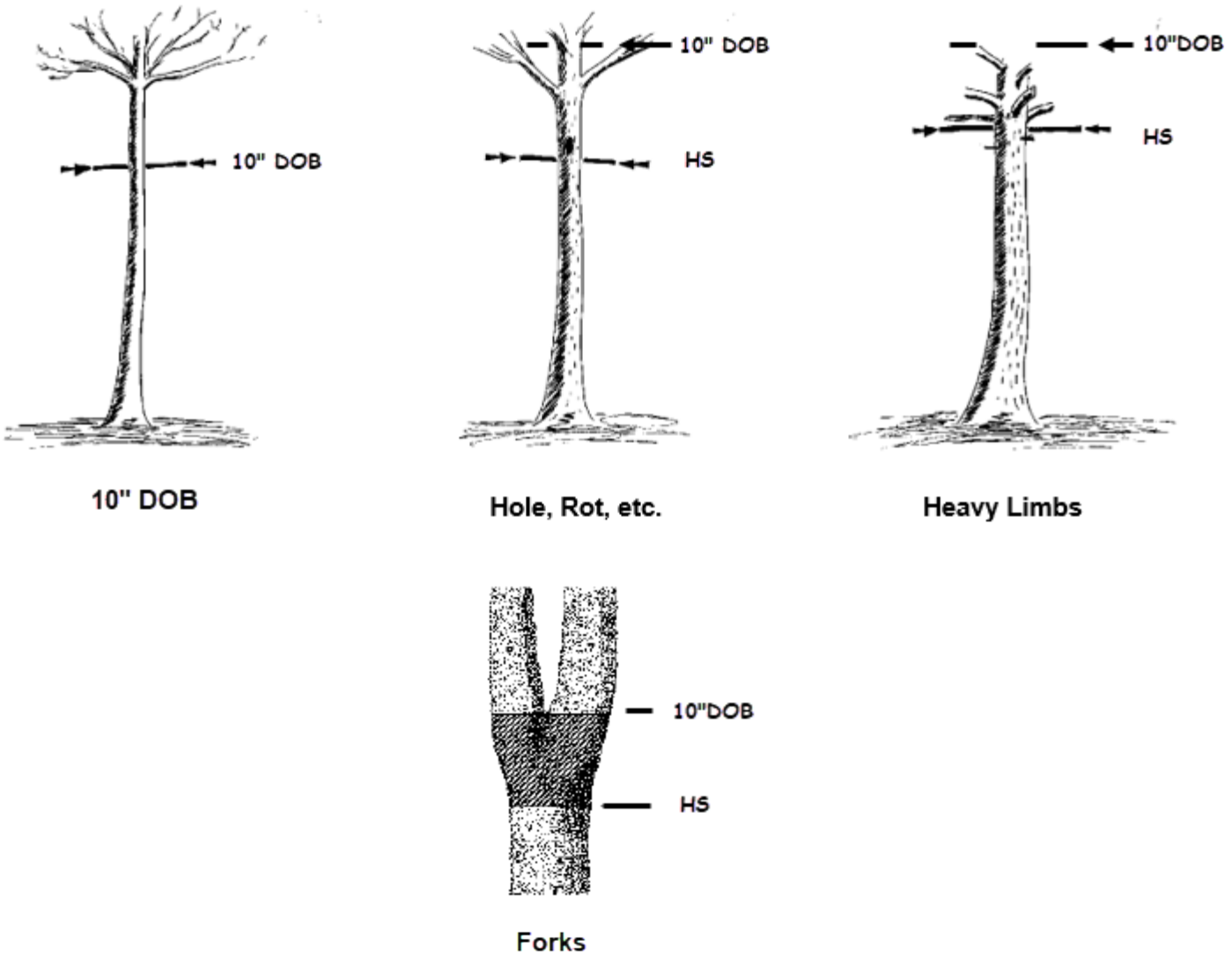


Figure 16 - Stoppers for Sawlogs

Deductions from Useable height

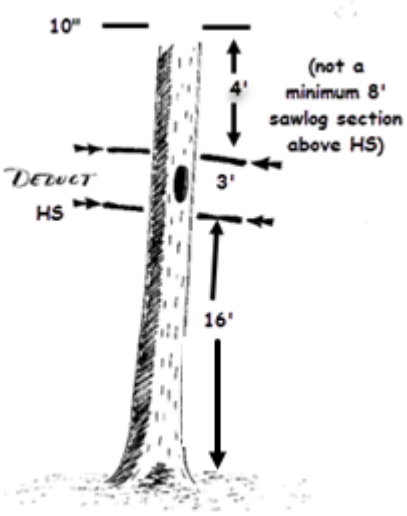
1. Hole, rot, etc
2. Crook
3. Excessive limbiness for sawlogs but not for pulpwood
4. Large diameter limb
5. Butt swell
6. “Junction” wood (double pith)
7. Clump of limbs
8. Bad seam
9. Catface
10. Excessive sweep

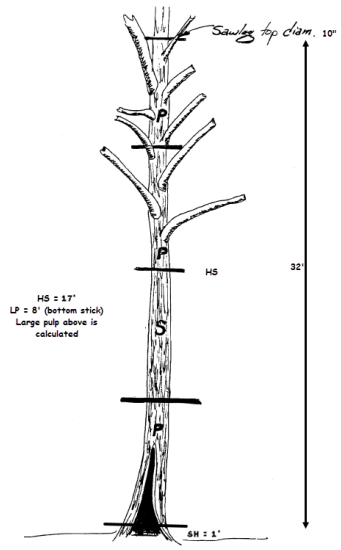
There are two possible sawlog deductions that can be measured. These are measured to the nearest foot:

1. Saw deduct that can be considered pulpwood (large pulp). These are recorded as **LP** (length in deduct to Large Pulpwood). They must be a minimum of 8' (100"), but can be any length greater than 8' to the nearest foot, e.g. 9', 13', 15', etc. The recorded deduct must also be below a length of sawlog, otherwise **HS** is recorded and anything above this point is calculated as pulpwood (i.e. **LP** only exists below or between sawlog portions). When calculating volume, the taper model will take the volume of large pulp deduct and subtract this volume from the sawlog portion of the tree and add the volume to the total pulpwood volume of the tree.

2. Saw deduct that contains non-merchantable wood. These are recorded as **DS** (length in Deduct of Sawlog). When calculating volume, the taper model will subtract this volume from the tree.

Merchantable lengths above or below deduct must be at least 8' in length.





Sawtimber Tally Tree with Large Pulp

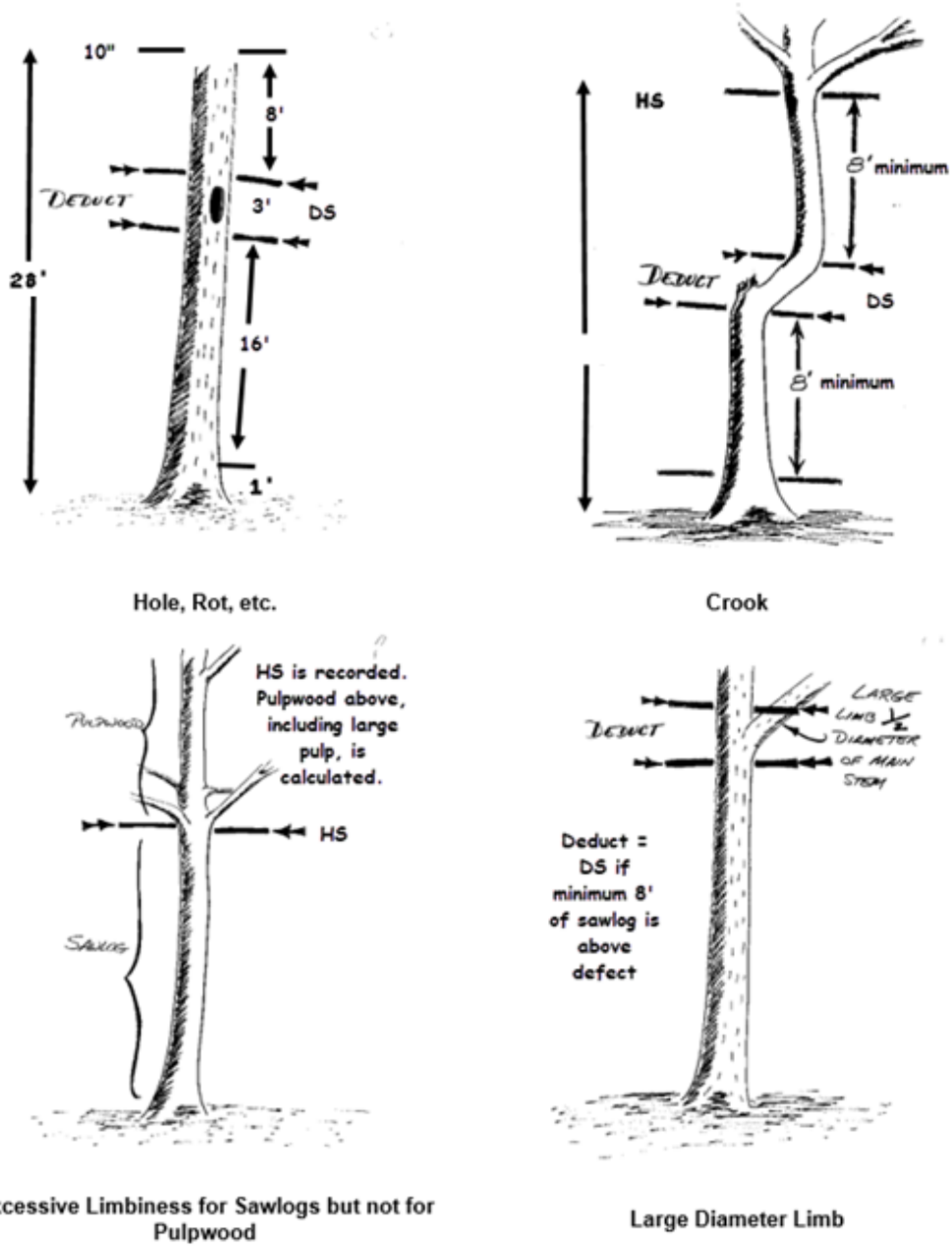


Figure 17 - Deductions from Useable Height for Sawlogs

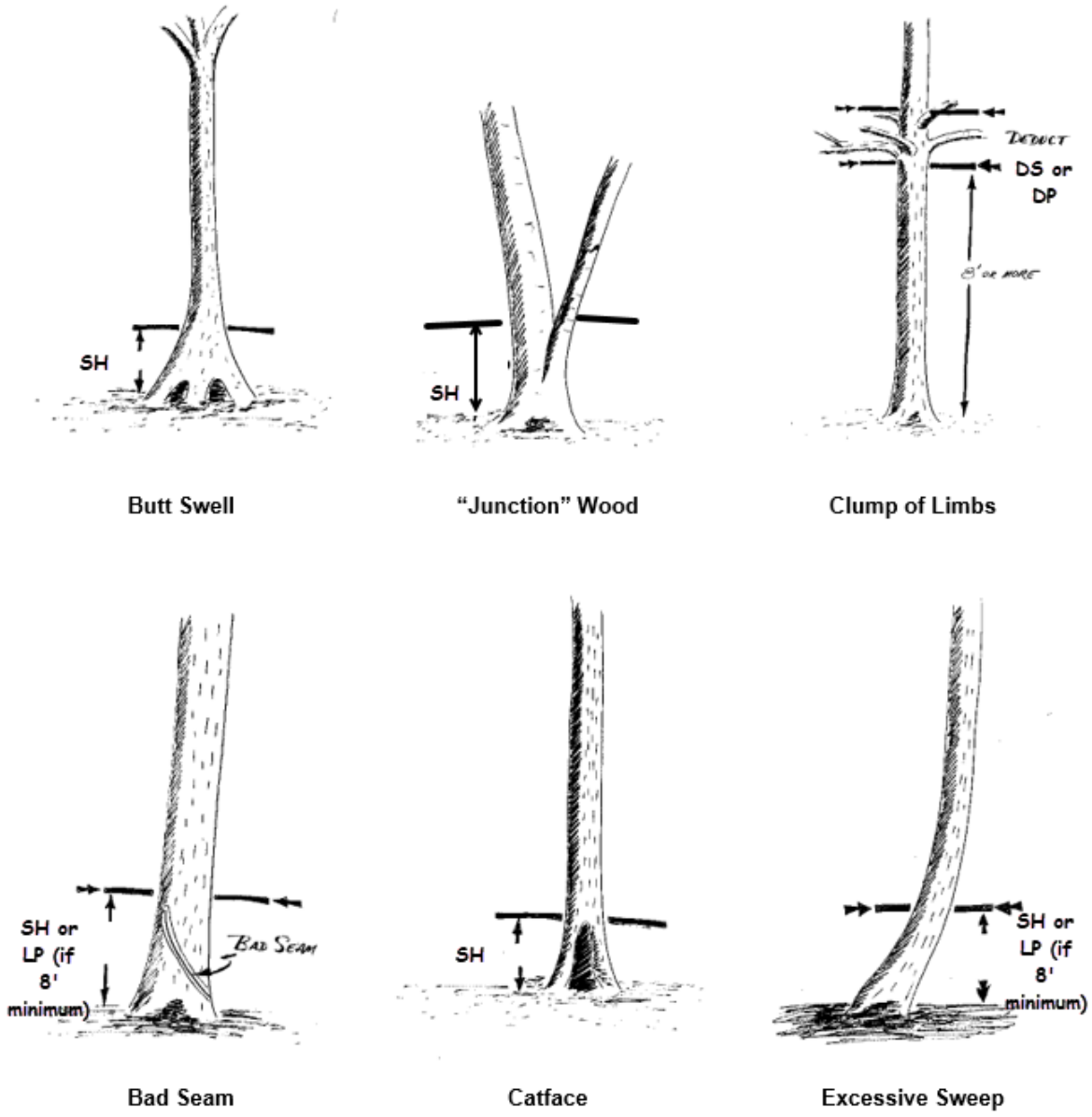


Figure 18 - More Deductions from Useable Height for Sawlogs

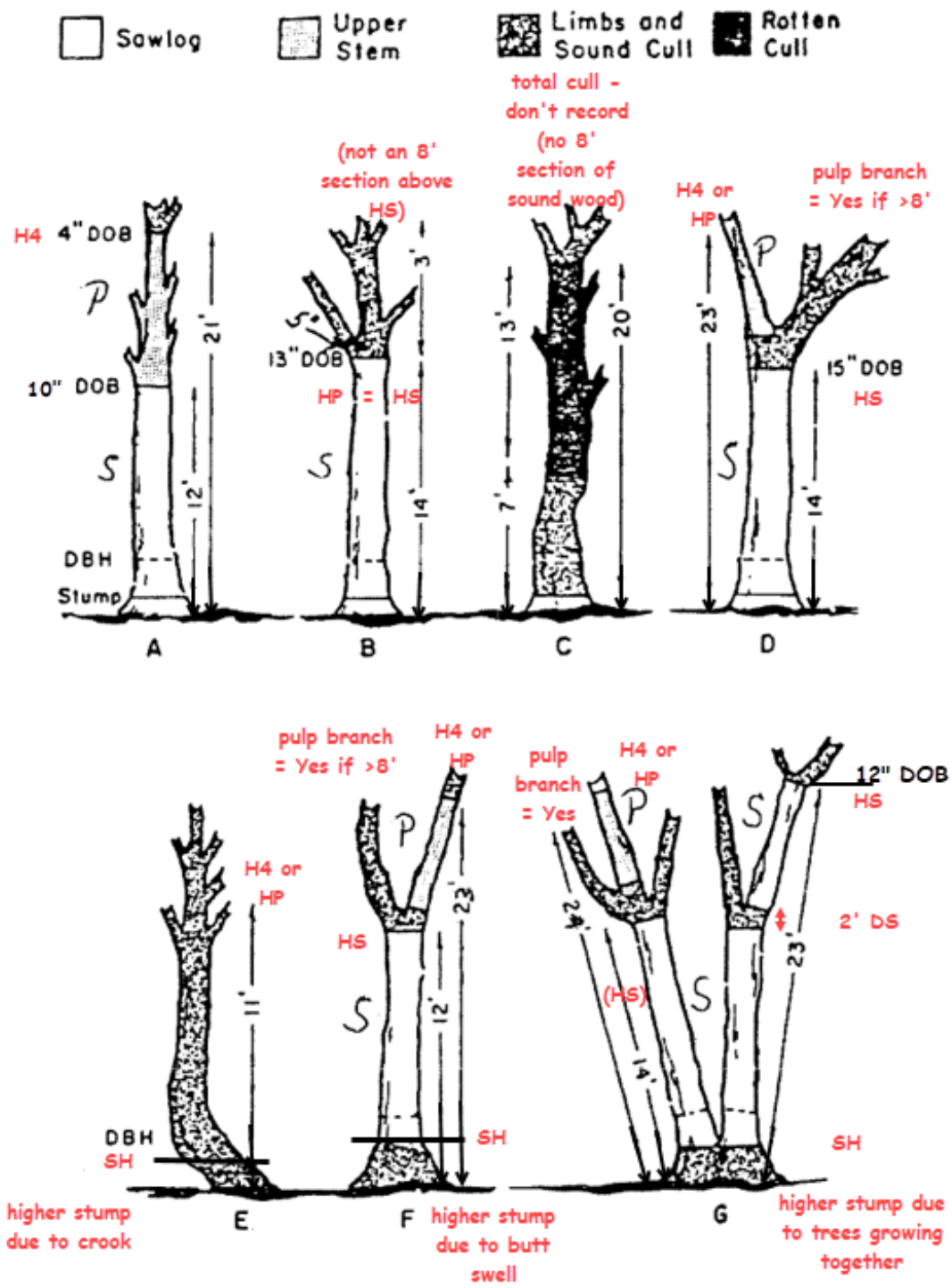
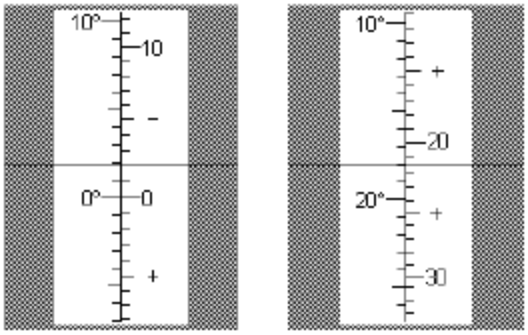


Figure 19 - Measuring Sawlog Trees

Height Measurements
There are numerous instruments used to measure heights, such as clinometer, relaskop, range finder, criterion, etc. Height measurements are recorded from ground level to the nearest foot. Become familiar with the type of instrument you are using. It's important to know what scale your instrument is using. Is the clinometer using Topo (66') and Percent, or Degrees? Some of these instruments can assist with top diameter also.

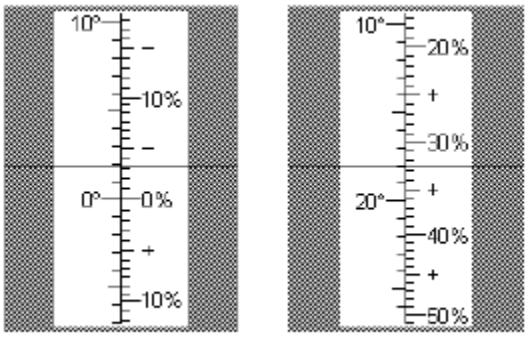
Height measurements using the clinometer usually use the Topo or Percent scale.

- Topo measurements are typically taken at 66' from the tree.
    - In this example, readings are using the right half of the scale



Bottom measurement Top measurement

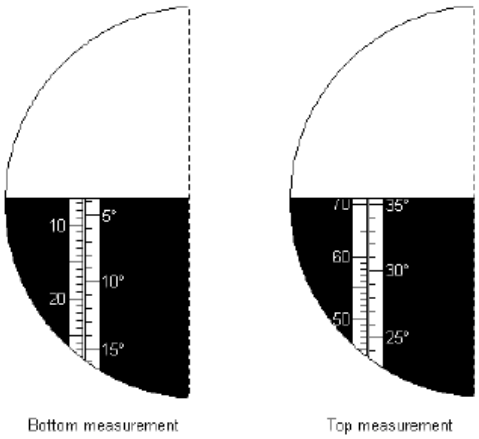
- Percent measurements are typically taken at 100' from the tree.
    - In this example, readings are using the right half of the scale.



Bottom measurement Top measurement

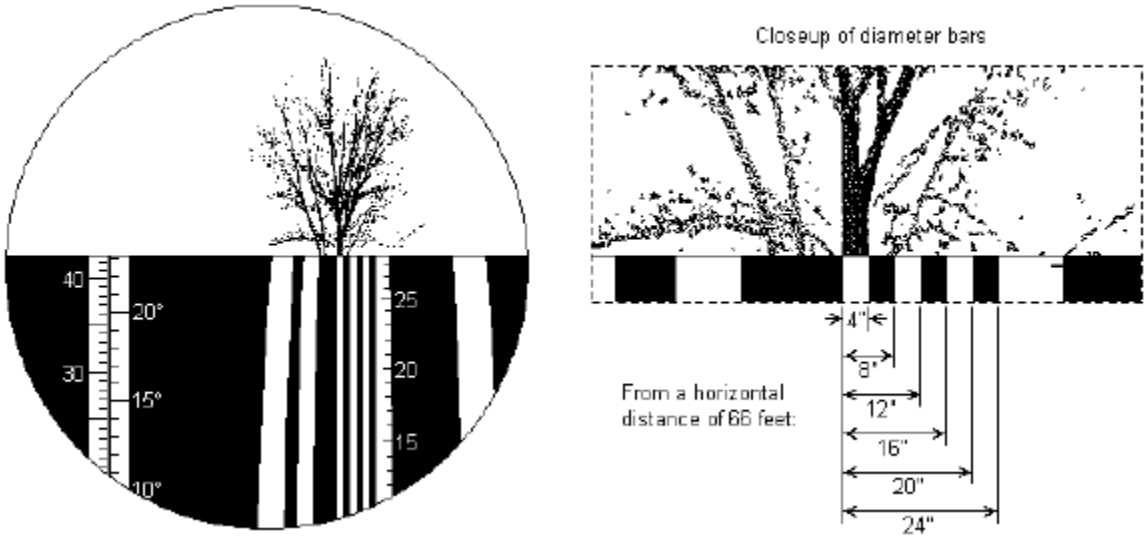
Height measurements using the relaskop are very similar to the clinometer.

- The scale typically has the percent scale on the left and degree scale on the right.



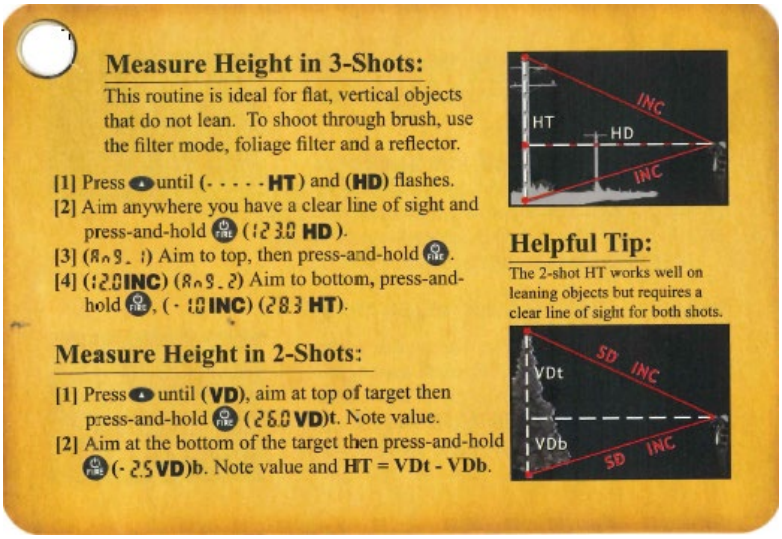
Bottom measurement Top measurement

- Heights to upper diameters can also be measured using the relaskop.



A range finder can typically take height measurements in two different ways.

- An example of TruPulse measurements:
-



The Criterion can be paired with the TruPulse and in addition to height measurements, like a relaskop, it can be used to find specific top diameters.

Height measurements recorded, as described in the previous sections, include:

- **H4** – pulpwood height to a 4” top DOB – AND/OR –
- **HP** – pulpwood height to a stopper present before **H4**
- **HS** – sawlog height to a stopper present before 10” DOB

Note: All height measurements (those with ‘H’ in their name) are measured from ground level, including Stump Height (**SH**).

CRUISING STANDARDS

Basics

1. Establishing Plot Center:

   It is necessary to establish a plot center at each point, so that it can be unquestionably determined whether any particular tree is “in” or “out” of the plot. The location must be marked by pin or stake, with flagging, so that it can be found again (for example, in a check cruise). Flagging must also be hung at, or near, plot center at eye level. GPS location of each point is encouraged.

2. Proper Basal Area Factor (BAF):

   When point sampling, use a BAF that matches stand density. Research has shown that approximately 4 to 8 “in” trees per point on average works best. Measuring too many trees increases cruiser error; measuring too few trees leads to increased variability (e.g. more plots needed for the same accuracy). For a single cruise area (strata), use the same BAF for the entire area. A larger BAF = fewer trees tallied; while a smaller BAF = more trees tallied. As an example, a 20 BAF may be best used in stands with a basal area of 100 square feet or higher. Conversely, a 10 BAF should be used in stands with a basal area under 100 square feet. Using a 5 BAF shouldn’t be overruled. This may be best in light hardwood selection cuts or low density stands. There are lots of BAF’s to consider. Aim for the ideal number of trees on a plot.

3. Measuring “In” or “Out” trees:

   A tree is considered “in” if the horizontal distance from plot center to the center of the tree at breast height is less than or equal to the plot radius. The angle gauge helps determine “in” or “out” trees. Trees that appear “borderline” shall be measured to determine whether to be recorded or not. The measurements needed are DBH of the tree (inches & tenths) and horizontal distance from plot center to the center of the tree at DBH (feet & tenths). DBH is rounded down to the tenth. For example, a tree that is 11.57 inches will be considered an 11.5-inch tree. DBH and distance are compared against the appropriate limiting distance table for the BAF used. A tree is either “in” or “out”. Limiting distance tables can either reference the “center” of the tree, or the “face” of the tree. Be sure you know if the table you are using is measuring to the center of the tree or the face of the tree. The DNR standard is a table that gives the distance to the center of the tree. *Be sure to know if your logger’s tape is graduated in inches or tenths of a foot!* It is imperative that the cruiser is taking enough time on each plot so as not to miss a tree in the tally.

   “[I]t must be remembered that smaller samples of any kind require larger expansion, or blow-up, factors. Thus, when point sampling is adopted, the so-called borderline trees must always be closely checked, for the erroneous addition or omission of a single stem can greatly reduce accuracy (Forest Measurements, 5th edition, Avery and Burkhart, 2002).”

4. Stratification:

   Stratification is the process in which the units of a sampled population are grouped together based on similarity of some characteristics. Each group or stratum is then sampled, and the group estimates are combined to give the total estimate. For example, if a sale consists of two stands, one is an R6 thinning and the other is an A6 clearcut. Each one of these stands is considered a separate stratum and would be sampled separately as its own Volume Determination Unit (VDU). The volume is computed for each stratum and the total is combined.

   On the other hand, you may be planning an aspen sale. You have three, A6 stands in your compartment that you are going to put up as one sale. Each stand is about the same age, growing after the section was harvested in the 1970’s. The basal area ranges from 70 to 90 and the average DBH is about 10”. The three stands could be considered as one stratum and cruised as a single VDU. This will require fewer plots to be taken. In this case, the volume is calculated at the VDU level, which is the same as the sale level. When creating the timber sale contract, the three stands could be separated into as many payment units as needed.

The following general rules should be used for stratification:

a. One Stand Sale
    i. Generally, one stand sales are designated as one strata/VDU, unless the stand can be divided into two or more separate stratum which are more uniform in basal area or volume per acre. If the stand is that variable and can be separated into smaller, more homogenous areas, then cruising as two or more VDU's could provide a better estimate of volume.

b. Multiple Stand Sale
    ii. If the stands are the same cover type and size density, indicating less variability in basal area and volume per acre, then the sale can be one stratum/VDU and each stand will be given the same VDU number. A typical example is a sale consisting of several stands of A6 that are to be clearcut.
    iii. If the stands are the same cover type but different size densities, then the stands should be divided into stratums/VDU's. For example, two stands of A6 and two stands of A4. The A6 stands will be one stratum/VDU and the A4 stands will be another stratum/VDU.
    iv. If the stands are of a different cover type and/or different treatments, each stand should be designated as a separate stratum/VDU. Consider the following stands:

Stand	Cover Type/Size Density	Treatment
1	A6	Clearcut
5	J5	Clearcut
6	M6	Thinning
8	R6	Thinning
10	P6	Thinning

Each of these stands will be given a separate stratum number, and you will have five strata/VDU's.

5. Achieved Error:
   Achieved error can be calculated at the VDU and sale area. We should strive for 10% to 20% achieved error at the sale level. If a 10% to 20% error is not achieved, then more plots may need to be taken. Conversely, if the achieved error is very good (say 5%), then less plots would have been needed to get the desired 10% accuracy. Our policy is that advertised sales have an achieved error of 10%, but not more than 20%, but we are not going to collect more than 1 sample point per acre. On smaller timber sales, for example those of 20 acres or less, a 20% achieved error may not be possible.
   Note that achieved error is based on overall volume per acre, for all species and all products for the entire sale. Statistical error will be greater at the VDU level. It will also be greater at the species/product level.

   Don't necessarily go above the "Rule of Thumb" on plots per acre, even if the achieved error isn't met. Some stands are just highly variable.

6. Number of Plots:
   The only accurate method of determining how many sample points should be measured is to determine the coefficient of variation of volume per acre from a preliminary field sample. When this has been done, sampling intensity may be derived by the following formula:

Formula:

n = [(*t*)(CV)] / A

Where:

n = number of plots needed to achieve precision of A, with probability level determined by *t*.

t = quantity from *t* distribution (generally taken as 1 for 67 percent and 2 for 95 percent probability levels, respectively)

CV = coefficient of variation, percent, from:

a. Historical data
b. Nearby similar stand
c. Forest inventory plot data
d. Several reconnaissance plots taken in the stand to be cruised

A = allowable error, percent = 10%

If preliminary data is not available, then the Rule of Thumb may be used. Be aware though, that for a large, homogeneous stand, the Rule will have you take more points than needed to achieve an acceptable achieved error. Save time and effort by using the Formula on larger stands.

Rule: "Rule of Thumb" by T. W. Beers and C. I. Miller:

a. Never take less than 10 sample points.
b. If the area is less than 40 acres, take one sample point for each acre (e.g., if 32 acres, take 32 points).
c. If the area contains from 40 to 80 acres, take 40 sample points, plus one sample point for every 2 acres over 40 acres. (e.g., 60 acres would require: 40 + [60-40]/2 = 50 points).
d. If the area contains from 80 to 200 acres, take 60 points, plus one sample point for every 4 acres over 80 acres. (e.g., 100 acres would require: 60 + [100-80]/4 = 65 points).
e. For area greater than 200 acres, use the formula.

Use the Formula or "Rule of Thumb", whichever indicates the lower number of plots with the following exceptions:

a. Generally, do not take more than one plot per acre.
b. Never take less than 10 plots on an area of 10 acres to 40 acres.
c. For sale area of 40 acres or more, take a minimum of 30 plots.

7. Boundary or Edge Points:

"Handling the edges of stands is one of the trickiest issues in forest inventory. Back in school, we all learned a variety of ways of dealing with plots that fall near the edge: the mirage method, the offset method, and even the "throw a stick in a random direction and that's the new plot center" method."

"…The takeaway: Cruise design should include a clearly established definition of what population you're trying to sample. If it's the legal ownership, or the GIS-established stand boundary, then you and your team should know that before you start. If you believe a plot location is going to be near the edge, but not on the edge, then navigate to the plot and measure it. Don't move it because the edge looks different from the rest of the stand—those are the conditions it's especially important to measure, to ensure that your sample is an unbiased inventory of the entire area."

"One final thought: Be especially careful with edges on smaller stands. Generally speaking, the smaller the stand, the more of the stand is "on the edge." You might be surprised to learn that in a circular stand with a diameter of four chains, more than 75 percent of the stand is within one chain of the edge!"

(Edges: Subtle Sources of Potential Bias, By Nan Pond, Forestry Source, November 2019, Vo. 24, No. 11. Society of American Foresters.)

The point cruising method is designed to work where trees from all directions and distances could potentially be "in". When a point center falls near the boundary of a unit, only those trees that are in the unit can be considered. This means that there are directions where trees from all distances cannot be considered. This problem commonly referred to as "edge-effect bias" or "boundary overlap", can introduce a bias in the point cruise statistics, if it is not treated properly. These types of points are called "boundary points" or "edge points". Points falling near forest edges must be adjusted for, particularly in small stands or long narrow stands. Failure to adjust for edge trees will result in a biased sampling method which will underestimate timber stand volume, because trees near the edge are less likely to be selected on a per unit stand/sale area basis.

When point sampling, staff should use the walkthrough method which diminishes or eliminates the need to work outside the tract and accommodates irregular boundaries easily. Under typical conditions, the walkthrough method eliminates the boundary overlap bias associated with most objects near the border and reduces it for the remaining objects.

Walkthrough: For any tree that is "in", measure the distance from the point center to the tree, then measure that same distance beyond the tree. In other words, walk through the tree the same distance the tree is from point center. If the ending point is outside the boundary, the tree is recorded a second time (Figure 25.).

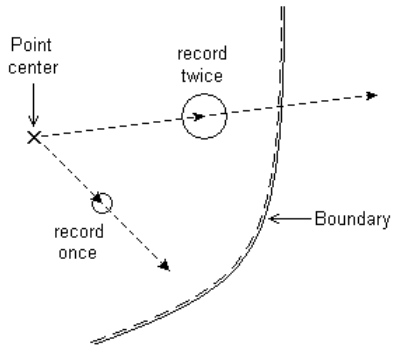


Figure 5 - Walkthrough Point

Decision Key: The decision key is entered whenever a tallied object appears close to the boundary.

I. Is it possible that the tallied object is closer to the boundary than to the sample point?
   Ia. NO – No action needed. Tally the object normally.
   Ib. YES – Proceed to II.

II. Measure the distance from the sample point to the object – call the distance x. Now measure the distance from the object to the boundary, continuing on the same bearing. Call this distance y. Is y less than x?
   IIa. NO – No action needed. Tally the object normally.
   IIb. YES – Proceed to III.

III. Does the boundary curve back across the walkthrough line?
   IIIa. NO – Walkthrough point must be outside the tract. Double-tally the object.
   IIIb. YES – Proceed to IV.

IV. Move to the walkthrough point, so that the distance to the object equals the previously measured distance along the same bearing, or to a point where that location can be clearly identified. Is the walkthrough point inside the tract?

IVa. NO – Double-tally the object.
IVb. YES – Tally the object normally.

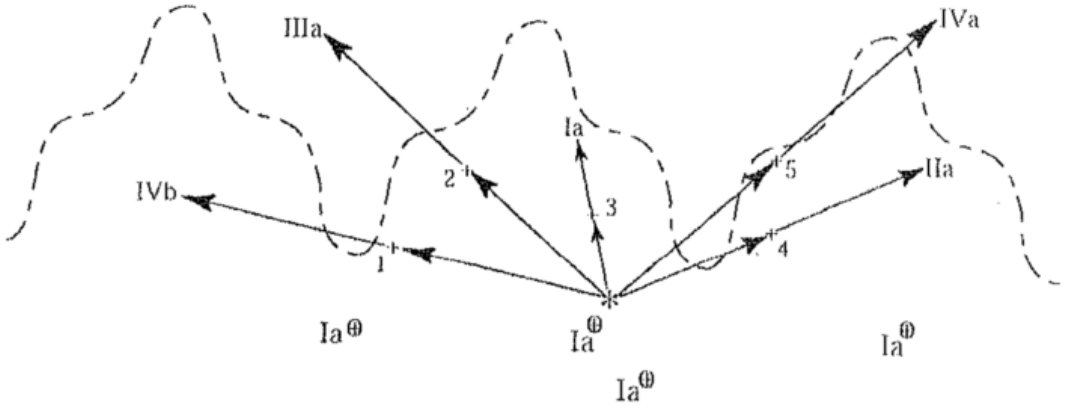


Figure 6 - Graphic Illustration of the Walkthrough Method

Five sample objects (+), lying close to the boundary, have been tallied from a sample point (*). The arrows indicate the layout of the walkthrough points for each object; the outcome on the key in Table 1 is indicated for each walkthrough point. Objects 1, 3, and 4 are tallied normally; objects 2 and 5 are double-tallied. Four objects (>) lie "close to the boundary", but in positions where they would be single-tallied, and no measurements would be needed.

The walkthrough method works well with curved or irregular boundaries. It also works even if a person cannot go beyond the boundary, i.e. the boundary is a fence, lake or cliff.

8. Michigan DNR Taper Model Measurements:
    a. Species (see Appendix)
    b. Product
        v. **1** - Saw
        vi. **2** - Pulp
        vii. **3** - Undifferentiated Volume
        viii. **6** - Subtract Tally
        ix. **7** - Snag
        x. **8** - Add Tally
        xi. **9** - Residual
    c. DBH (to the nearest 1" class; can record to 1/10")
    d. Merchantable Height (to the nearest 1' from ground level)
        xii. **H4** – pulpwood height to a 4" top DOB – AND/OR –
        xiii. **HP** – pulpwood height to a stopper present before **H4**
        xiv. Sawlog height is generally calculated based on **H4** or **HP**, unless a stopper is present
        xv. **HS** – sawlog height to a stopper present before 10" DOB
    e. Stump Height (to the nearest 1/10')
        xvi. Stump height is defaulted to a specific height at the stand level. If other than the default, record as **SH** to the nearest 1/10 foot.
    f. Defect (to the nearest 1')
        xvii. **DP** – record length of defect in pulpwood (cull)
        xviii. **DS** – record length of defect in sawlogs (cull)
        xix. **LP** – record length of defect in sawlogs (large pulp) – must be in at least 8' sections
    g. Merchantable Branchwood (if present) **Br**
        xx. **0** - if no merchantable branchwood is present
        xxi. **1** - if merchantable sawlog is present in a branch(es)

xxii. **2** - if merchantable pulpwood is present in a branch(es)
xxiii. **3** - if both saw and pulp are present in a branch(es)

VARIABLE RADIUS SUB-SAMPLING (VRSS)

Variable radius sub-sampling (VRSS) is a variable radius plot sampling protocol that utilizes taper models to determine volumes of measured trees. It allows for sub-sampling of diameters and heights that are extrapolated across all trees counted as 'in'. The cruiser would only record species, product, diameter, merchantable heights, branches and deduct for a portion of the 'in' trees. Residual BA information would be recorded on all partial harvests.

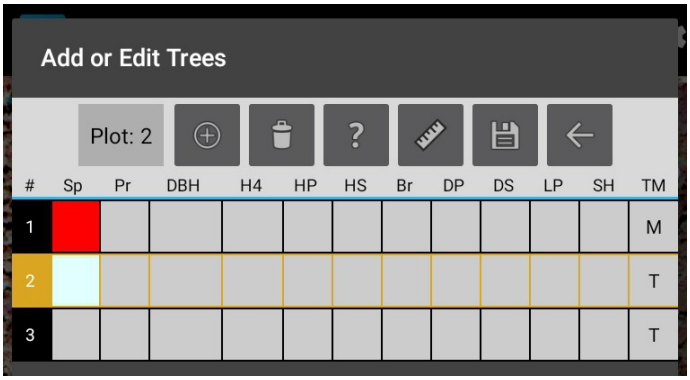
Field protocols
What is Recorded:

- At the Cruise Level:
  - *OBJECTID**:
  - *Management Type**: State Forests (default)
  - *District**: (drop-down)
  - *Management Unit**: (drop-down)
  - *Compartment**: (fill-in)
  - *VDU ID*: (optional fill-in)
  - *FCS Key*: (optional fill-in)
  - *Acres**: (will be derived from the spatial record in our inventory identified in the cruise name)
  - *Contract/State*: State (default)
  - *Cruiser ID**: (set default in settings)
  - *Purpose**: (drop-down) [Timber Sale, Inventory, Other, Check Cruise]
  - *Plot Type**: (drop-down) [BAF, BAF+resid, Tally, Fixed]
  - *BAF or Plot Size**: (drop-down) [Tally, 5, 10, 15, 20, 25, 30, 35, 40, Fixed 1/20, Fixed 1/10, Fixed 1/5, Fixed ¼, Fixed 1/3, Fixed ½]
  - *Sample Type**: (drop-down) [STR, FTN, PCMM/PCMC, BB]
  - *Sample Tree Ratios*: (add - based on species/products)
  - *Status*: Planned (default) [Planned, Active, Cruised, Checked Archived]
  - *Residual BAF Plot Density*: (drop-down) [1:03, 1:02, 1:01, null]
  - *Residual BAF*: (drop-down) [Tally, 5, 10, 15, 20, 25, 30, 35, 40, Fixed 1/20, Fixed 1/10, Fixed 1/5, Fixed ¼, Fixed 1/3, Fixed ½]
  - *Big BAF*: (drop-down) [None, 10, 20, 30, 40, 50, 60, 70, 80]
  - *Stump Height*: 1.0 (default)
  - *Cut Percent*: 100 (default)
  - *PCTM Ratio*: (drop-down) [1:05, 1:03, 1:02, 1:01]
  - *Notes*: (optional fill-in)
  - *Photos*: (not configured)
  - *Contractor Name*: (fill-in; required if Contract/State = Contract)

- **At the Plot Level: (**the only thing managed at this level is **Status)**
  - *OBJECTID**:
  - ***Status***: Planned – MUST CHANGE TO "Cruised" WHEN COMPLETE
  - *Management Type**: (carried forward from Cruise attributes)
  - *District**: (carried forward from Cruise attributes)
  - *Management Unit**: (carried forward from Cruise attributes)
  - *Compartment**: (carried forward from Cruise attributes)
  - *VDU ID*: (carried forward from Cruise attributes)
  - *FCS Key*: (carried forward from Cruise attributes)
  - *Plot ID**: (determined from program or fill-in)
  - *Contract or State*: (carried forward from Cruise attributes)
  - *Cruiser ID**: (carried forward from Cruise attributes)
  - *Purpose**: (carried forward from Cruise attributes)

- *Plot Type**: (carried forward from Cruise attributes)
- *BAF or Plot Size**: (carried forward from Cruise attributes)
- *Sample Type**: (carried forward from Cruise attributes)
- *Sample Tree Ratios*: (carried forward from Cruise attributes)
- *Residual BAF*: (carried forward from Cruise attributes)
- *Big BAF**: (carried forward from Cruise attributes)
- *Stump Height*: (carried forward from Cruise attributes)
- *Cut Percent**: (carried forward from Cruise attributes)
- *PCTM Ratio*: (carried forward from Cruise attributes)
- *Notes*: (fill-in)
- *Photos*: (not configured)
- *Contractor Name*: (carried forward from Cruise attributes)
- *Calc Residual BA*
- *Calc Merch BA*
- *Calc Snag BA*
- *Calc Saw BA*

- At the Tree Level:
  - **Sp** (species)
  - **Pr** (product)
    - **1** – saw
    - **2** – pulp
    - **3** – undifferentiated volume
    - **6** – subtract tally
    - **7** – snag
    - **8** – add tally
    - **9** – residual
  - **DBH**
  - **H4** (height in 1’ increments to a 4” top from ground level)
  - **HP** and/or **HS** (only when there is a ‘stopper’ for pulp or saw height)
  - **Br**
    - **0** – no merchantable branches present
    - **1** – merchantable saw in branches
    - **2** – merchantable pulp in branches
    - **3** – both merchantable saw and pulp in branches
  - **DP** or **DS** or **LP** [recorded as a length of deduction in feet, if there is unmerchantable material in middle of the pulp (**DP**) or saw (**DS**) portion of the tree or large pulp (**LP**) in saw portion of the tree]
  - **SH** (stump height if other than default)
  - Based on the inputted Sample Tree Ratios at the Cruise Level, the **TM** column will show which tree is a T (tally) or M (measure) tree. Tally trees just need **Sp** and **Pr** inputs.



Sample Types

1. **Sample Tree Ratio (STR):**
   Trees, by species/product, may be measured by different intensities. High value species/products may be measure with a higher intensity (1:5) than low value species/products (1:10); or they may all be measured with the same intensity. Measure trees will record all information as defined above. Tally trees just record Species (**Sp**) and Product (**Pr**).

2. **Big BAF (BB):**
   A basal area factor larger than that used to determine the 'in' trees is used to select the measure trees. Trees that are 'in' with the larger BAF are the trees that need to be measured. The size of the Big BAF is determined by the number of trees that need to be measured. A BAF twice as large as that used to determine 'in' trees should identify about half of the trees for measuring. A BAF four times as large should identify about one-fourth of the trees for measuring. The small BAF are the tally trees (**Sp** and **Pr** inputs); the large BAF are measure trees (recorded as above).

3. **Measure/Count plots (PCMM/PCMC):**
   All trees are measured on some proportion of points, and simply counted on the other points. The "measure plots" will record the tree information as above. The "count plots" will count the 'in' trees in by species (**Sp**) and product (**Pr**).

4. **First Tree North (FTN):**
   The first tree, by species/product, starting from North is measured. The tree counts for each sample group are then recorded by each measure tree.

TALLY CRUISE

This protocol would be used for determining the volume of individual trees. It would likely be used most frequently for determining the value of individual trees (timber sale contract amendments for landings and roads, trespasses, etc.) or for determining total volume of small or irregular shaped areas that are not conducive to the VRSS variable radius plot sampling described above. Examples include linear right-of-way clearings, or other small/narrow/highly variable/valuable stands where it is efficient to tally individual trees, and the statistics for variable plot radius cruises would be unacceptable. Note that this cruise protocol has no spatial component for its measurements, other than the summary being tied to a cruise polygon.

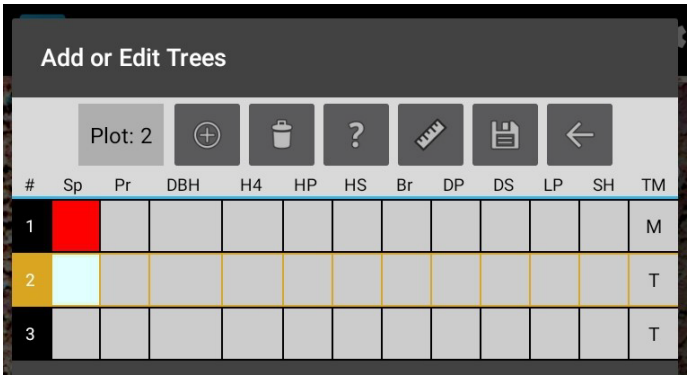
It is important to emphasize that this protocol would be the exception for determining volumes on timber sales and is only recommended for the situations described in the examples above. The traditional mark and tally method used in some areas for volume determination in hardwood stands (and to a lesser degree in a few other types) would be replaced by the VRSS protocol.

Field Protocol
What is recorded:

- At the Cruise Level:
  - *OBJECTID**:
  - *Management Type**: State Forests (default)
  - *District**: (drop-down)
  - *Management Unit**: (drop-down)
  - *Compartment**: (fill-in)
  - *VDU ID*: (optional fill-in)
  - *FCS Key*: (optional fill-in)
  - *Acres**: (will be derived from the spatial record in our inventory identified in the cruise name)
  - *Contract/State*: State (default)
  - *Cruiser ID**: (set default in settings)
  - *Purpose**: (drop-down) [Timber Sale, Inventory, Other, Check Cruise]
  - *Plot Type**: (drop-down) [BAF, BAF+resid, **Tally**, Fixed]
  - *BAF or Plot Size**: (drop-down) [**Tally**, 5, 10, 15, 20, 25, 30, 35, 40, Fixed 1/20, Fixed 1/10, Fixed 1/5, Fixed ¼, Fixed 1/3, Fixed ½]

- *Sample Type**: (drop-down) [**STR**, FTN, PCMM/PCMC, BB]
- *Sample Tree Ratios*: (add - based on species/products)
- *Status*: Planned (default) [Planned, Active, Cruised, Checked Archived]
  - MUST CHANGE TO “Cruised” WHEN COMPLETE
- *Residual BAF Plot Density*: (drop-down) [1:03, 1:02, 1:01, null]
- *Residual BAF*: (drop-down) [Tally, 5, 10, 15, 20, 25, 30, 35, 40, Fixed 1/20, Fixed 1/10, Fixed 1/5, Fixed ¼, Fixed 1/3, Fixed ½]
- *Big BAF*: (drop-down) [None, 10, 20, 30, 40, 50, 60, 70, 80]
- *Stump Height*: 1.0 (default)
- *Cut Percent*: 100 (default)
- *PCTM Ratio*: (drop-down) [1:05, 1:03, 1:02, 1:01]
- *Notes*: (optional fill-in)
- *Photos*: (not configured)
- *Contractor Name*: (fill-in; required if Contract/State = Contract)

- At the Tree Level:
  - **Sp** (species)
  - **Pr** (product)
    - **1** – saw
    - **2** – pulp
    - **3** – undifferentiated volume
    - **6** – subtract tally
    - **7** – snag
    - **8** – add tally
    - **9** – residual
  - **DBH**
  - **H4** (height in 1’ increments to a 4” top from ground level)
  - **HP** and/or **HS** (only when there is a ‘stopper’ for pulp or saw height)
  - **Br**
    - **0** – no merchantable branches present
    - **1** – merchantable saw in branches
    - **2** – merchantable pulp in branches
    - **3** – both merchantable saw and pulp in branches
  - **DP** or **DS** or **LP** [recorded as a length of deduction in feet, if there is unmerchantable material in middle of the pulp (**DP**) or saw (**DS**) portion of the tree or large pulp (**LP**) in saw portion of the tree]
  - **SH** (stump height if other than default)
  - Each tree gets its own row



APPENDICES

Appendix A: Species Codes

CODE	DESCRIPTION
1	Sugar Maple
2	American Elm
3	Red Maple
4	Yellow Birch
5	Basswood
6	White Ash
7	Beech
8	Red Oak
9	White Oak
10	Paper Birch
11	Quaking Aspen
12	Bigtooth Aspen
13	Black/Red (Hybrid) Oak
14	Northern Pin Oak
15	Balsam Poplar
20	Balsam Fir
21	White Spruce
22	Black Spruce
25	Northern White Cedar
27	Tamarack
30	White Pine
31	Red Pine
32	Jack Pine
37	Austrian Pine
39	Hemlock
41	Black Ash
42	Green Ash
49	Black Cherry
53	Rock Elm
61	Ironwood
68	Eastern Red Cedar
71	Larch (non-native)
90	Misc. Species 1
91	Misc. Species 2
92	Norway Spruce
93	Misc. Species 3
94	Misc. Species 4
95	Misc. Species 5
96	Blue Spruce
130	Scotch Pine
202	Douglas Fir
313	Boxelder
314	Black Maple
315	Striped Maple
317	Silver Maple
319	Mountain Maple
320	Norway Maple
330	Horsechestnut
331	Buckeye
341	Tree of Heaven

355	Black/European Alder
356	Serviceberry (Juneberry)
367	Pawpaw
391	Musclewood/Hornbeam
402	Bitternut Hickory
403	Pignut Hickory
405	Shellbark Hickory
407	Shagbark Hickory
421	American Chestnut
452	Catalpa
462	Hackberry
471	Eastern Redbud
546	Blue Ash
552	Honeylocust
601	Butternut
602	Black Walnut
621	Yellow Poplar (Tulip Tree)
641	Osage Orange
660	Apple (spp.)
681	White Mulberry
682	Red Mulberry
693	Blackgum
731	Sycamore
742	Cottonwood
744	Swamp Cottonwood
761	Pin Cherry
771	Sweet Cherry
804	Swamp White Oak
806	Scarlet Oak
817	Shingle Oak
823	Bur Oak
826	Chinkapin Oak
830	Pin Oak (Southern)
901	Black Locust
921	Peachleaf Willow
922	Black Willow
929	Weeping Willow
931	Sassafras
935	Mountain Ash
975	Slippery Elm

Appendix B: Definitions and Acronyms

Basal Area: term used to describe the average amount of an area (usually an acre) occupied by tree stems. It is defined as the total cross-sectional area of all stems in a stand measured at breast height and expressed as per unit of land area (typically square feet per acre).

BAF / Basal Area Factor: used in variable radius plot sampling to estimate basal area per acre. A factor is chosen (commonly BAF 10 or 20 in Michigan) and an instrument (wedge prism, angle gauge, relaskop, etc.) calibrated to that factor is used to determine if sample trees are 'in' for sampling or not. Trees that are 'borderline' or too close to call with the instrument have their distance checked to mathematically determine if they are 'in'.

- **'In' trees:** a tree determined to be part of a sample on a variable radius plot.

Br: branches
- 0 – none
- 1 – saw in branches
- 2 – pulp in branches
- 3 – saw and pulp in branches

DBH: diameter at breast height (measured at 4.5’ above ground level)

DOB: diameter outside bark

DP: length (in feet) in deduct of pulp (cull portion)

DS: length (in feet) in deduct of saw (cull portion)

H4 / Height to a 4” top: measurement (in feet) of a tree from ground level until it reaches a point where the diameter of the stem is 4” (outside of the bark).

HP / Height to Pulp stopper: measurement (in feet) of a tree from ground level until it reaches a point that beyond no longer meets definition of a pulp stick. This point is only recorded when the transition to unmerchantability occurs abruptly at a point where the stem diameter is >4” (usually a fork, large limb(s), or another defect).

HS / Height to Saw stopper: measurement (in feet) of a tree from ground level until it reaches a point that beyond no longer meets definition of a sawlog. This point is calculated for naturally tapering trees and is a recorded measurement/observation when the transition to pulpwood occurs abruptly because of a fork, large limb(s), or another defect.

LP / Large Pulp: measurement (in feet) of large pulp below a length of sawlog. Must be a minimum of 8’ (100”).

Pr / Product
- 1 – saw
- 2 – pulp
- 3 – undifferentiated volume
- 6 – subtract tally
- 7 – snag
- 8 – add tally
- 9 – residual
-

SH / Stump Height: measurement (in tenths of feet) from ground level to height where tree is felled.

Sp / Species: see Species List Appendix A for species codes.

VRSS / Variable radius sub-sampling: A collection of protocols that alleviate the need to take diameter and height measurements on every sample tree in a plot.

- **Sample Tree Ratio / STR:** trees, by species/product, measured with different intensities.
- **Big BAF / BB:** small BAF used to record tally trees; larger BAF used to record measure trees.
- **Point Count Measure / PCMM/PCMC:** PCM Measure – measure plots; PCM Count – tally plots
- **First Tree North / FTN:** the first tree, by species/product, starting from North is measured.

Cruise Level Attributes:
VDU ID – Volume Determination Unit (used for cruise strata)

FCS Key – Forest Compartment Stand Key

e.g. 42012020 (42 = Newberry FMU, 012 = Compartment number, 020 = stand number)

Purpose
- Timber Sale
- Inventory
- Other
- Check Cruise

Plot Type
- BAF
- BAF+resid
- Tally
- Fixed

BAF or Plot Size
- Tally
- BAF (5, 10, 15, 20, 25, 30, 35, 40)
- Fixed (1/20, 1/10, 1/5, ¼, 1/3, ½)

Sample Type
- STR (Sample Tree Ratio)
- FTN (First Tree North)
- PCMM/PCMC (Point Count or Measure)
- BB (Big BAF)
- None

Status
- Planned
- Active
- Cruised
- Checked
- Archived

Residual BAF Plot Density
- 1:03
- 1:02
- 1:01
- Null

Residual BAF
- Tally
- BAF (5, 10, 15, 20, 25, 30, 35, 40)
- Fixed (1/20, 1/10, 1/5, ¼, 1/3, ½)

Big BAF
- None
- BAF (10, 20, 30, 40, 50, 60, 70, 80)

PCTM Ratio
- 1:05
- 1:03
- 1:02
- 1:01

Appendix C: Plot radius factors also known as limiting distance tables

- Plot radius factor = PRF
  To calculate plot radius factors, measure from plot center to the middle of the tree not the face of the tree.
- Basal area factor = BAF
- Diameter breast height = DBH

PRF*DBH

BAF	Factor
5	3.889
10	2.75
15	2.245
20	1.944
25	1.739
30	1.588
35	1.47
40	1.375
50	1.23
60	1.123
70	1.039
80	0.972

PRF= 8.696/SQR(BAF)

For all tables in the following pages, the following information applies:

- The plot radius is from plot center to the center of the tree.
- All distance measurements are in feet and tenths.
- All tree diameters are in inches and tenths.

PLOT RADIUS FACTOR FOR 5 FACTOR (3.889)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	15.56	15.94	16.33	16.72	17.11	17.50	17.89	18.28	18.67	19.06
5	19.45	19.83	20.22	20.61	21.00	21.39	21.78	22.17	22.56	22.95
6	23.33	23.72	24.11	24.50	24.89	25.28	25.67	26.06	26.45	26.83
7	27.22	27.61	28.00	28.39	28.78	29.17	29.56	29.95	30.33	30.72
8	31.11	31.50	31.89	32.28	32.67	33.06	33.45	33.83	34.22	34.61
9	35.00	35.39	35.78	36.17	36.56	36.95	37.33	37.72	38.11	38.50
10	38.89	39.28	39.67	40.06	40.45	40.83	41.22	41.61	42.00	42.39
11	42.78	43.17	43.56	43.95	44.33	44.72	45.11	45.50	45.89	46.28
12	46.67	47.06	47.45	47.83	48.22	48.61	49.00	49.39	49.78	50.17
13	50.56	50.95	51.33	51.72	52.11	52.50	52.89	53.28	53.67	54.06
14	54.45	54.83	55.22	55.61	56.00	56.39	56.78	57.17	57.56	57.95
15	58.34	58.72	59.11	59.50	59.89	60.28	60.67	61.06	61.45	61.84
16	62.22	62.61	63.00	63.39	63.78	64.17	64.56	64.95	65.34	65.72
17	66.11	66.50	66.89	67.28	67.67	68.06	68.45	68.84	69.22	69.61
18	70.00	70.39	70.78	71.17	71.56	71.95	72.34	72.72	73.11	73.50
19	73.89	74.28	74.67	75.06	75.45	75.84	76.22	76.61	77.00	77.39
20	77.78	78.17	78.56	78.95	79.34	79.72	80.11	80.50	80.89	81.28
21	81.67	82.06	82.45	82.84	83.22	83.61	84.00	84.39	84.78	85.17
22	85.56	85.95	86.34	86.72	87.11	87.50	87.89	88.28	88.67	89.06
23	89.45	89.84	90.22	90.61	91.00	91.39	91.78	92.17	92.56	92.95
24	93.34	93.72	94.11	94.50	94.89	95.28	95.67	96.06	96.45	96.84
25	97.23	97.61	98.00	98.39	98.78	99.17	99.56	99.95	100.34	100.73
26	101.11	101.50	101.89	102.28	102.67	103.06	103.45	103.84	104.23	104.61
27	105.00	105.39	105.78	106.17	106.56	106.95	107.34	107.73	108.11	108.50
28	108.89	109.28	109.67	110.06	110.45	110.84	111.23	111.61	112.00	112.39
29	112.78	113.17	113.56	113.95	114.34	114.73	115.11	115.50	115.89	116.28
30	116.67	117.06	117.45	117.84	118.23	118.61	119.00	119.39	119.78	120.17

PLOT RADIUS FACTOR FOR 10 FACTOR (2.750)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	11.00	11.28	11.55	11.83	12.10	12.38	12.65	12.93	13.20	13.48
5	13.75	14.03	14.30	14.58	14.85	15.13	15.40	15.68	15.95	16.23
6	16.50	16.78	17.05	17.33	17.60	17.88	18.15	18.43	18.70	18.98
7	19.25	19.53	19.80	20.08	20.35	20.63	20.90	21.18	21.45	21.73
8	22.00	22.28	22.55	22.83	23.10	23.38	23.65	23.93	24.20	24.48
9	24.75	25.03	25.30	25.58	25.85	26.13	26.40	26.68	26.95	27.23
10	27.50	27.78	28.05	28.33	28.60	28.88	29.15	29.43	29.70	29.98
11	30.25	30.53	30.80	31.08	31.35	31.63	31.90	32.18	32.45	32.73
12	33.00	33.28	33.55	33.83	34.10	34.38	34.65	34.93	35.20	35.48
13	35.75	36.03	36.30	36.58	36.85	37.13	37.40	37.68	37.95	38.23
14	38.50	38.78	39.05	39.33	39.60	39.88	40.15	40.43	40.70	40.98
15	41.25	41.53	41.80	42.08	42.35	42.63	42.90	43.18	43.45	43.73
16	44.00	44.28	44.55	44.83	45.10	45.38	45.65	45.93	46.20	46.48
17	46.75	47.03	47.30	47.58	47.85	48.13	48.40	48.68	48.95	49.23
18	49.50	49.78	50.05	50.33	50.60	50.88	51.15	51.43	51.70	51.98
19	52.25	52.53	52.80	53.08	53.35	53.63	53.90	54.18	54.45	54.73
20	55.00	55.28	55.55	55.83	56.10	56.38	56.65	56.93	57.20	57.48
21	57.75	58.03	58.30	58.58	58.85	59.13	59.40	59.68	59.95	60.23
22	60.50	60.78	61.05	61.33	61.60	61.88	62.15	62.43	62.70	62.98
23	63.25	63.53	63.80	64.08	64.35	64.63	64.90	65.18	65.45	65.73
24	66.00	66.28	66.55	66.83	67.10	67.38	67.65	67.93	68.20	68.48
25	68.75	69.03	69.30	69.58	69.85	70.13	70.40	70.68	70.95	71.23
26	71.50	71.78	72.05	72.33	72.60	72.88	73.15	73.43	73.70	73.98
27	74.25	74.53	74.80	75.08	75.35	75.63	75.90	76.18	76.45	76.73
28	77.00	77.28	77.55	77.83	78.10	78.38	78.65	78.93	79.20	79.48
29	79.75	80.03	80.30	80.58	80.85	81.13	81.40	81.68	81.95	82.23
30	82.50	82.78	83.05	83.33	83.60	83.88	84.15	84.43	84.70	84.98

PLOT RADIUS FACTOR FOR 15 FACTOR (2.245)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	8.98	9.20	9.43	9.65	9.88	10.10	10.33	10.55	10.78	11.00
5	11.23	11.45	11.67	11.90	12.12	12.35	12.57	12.80	13.02	13.25
6	13.47	13.69	13.92	14.14	14.37	14.59	14.82	15.04	15.27	15.49
7	15.72	15.94	16.16	16.39	16.61	16.84	17.06	17.29	17.51	17.74
8	17.96	18.18	18.41	18.63	18.86	19.08	19.31	19.53	19.76	19.98
9	20.21	20.43	20.65	20.88	21.10	21.33	21.55	21.78	22.00	22.23
10	22.45	22.67	22.90	23.12	23.35	23.57	23.80	24.02	24.25	24.47
11	24.70	24.92	25.14	25.37	25.59	25.82	26.04	26.27	26.49	26.72
12	26.94	27.16	27.39	27.61	27.84	28.06	28.29	28.51	28.74	28.96
13	29.19	29.41	29.63	29.86	30.08	30.31	30.53	30.76	30.98	31.21
14	31.43	31.65	31.88	32.10	32.33	32.55	32.78	33.00	33.23	33.45
15	33.68	33.90	34.12	34.35	34.57	34.80	35.02	35.25	35.47	35.70
16	35.92	36.14	36.37	36.59	36.82	37.04	37.27	37.49	37.72	37.94
17	38.17	38.39	38.61	38.84	39.06	39.29	39.51	39.74	39.96	40.19
18	40.41	40.63	40.86	41.08	41.31	41.53	41.76	41.98	42.21	42.43
19	42.66	42.88	43.10	43.33	43.55	43.78	44.00	44.23	44.45	44.68
20	44.90	45.12	45.35	45.57	45.80	46.02	46.25	46.47	46.70	46.92
21	47.15	47.37	47.59	47.82	48.04	48.27	48.49	48.72	48.94	49.17
22	49.39	49.61	49.84	50.06	50.29	50.51	50.74	50.96	51.19	51.41
23	51.64	51.86	52.08	52.31	52.53	52.76	52.98	53.21	53.43	53.66
24	53.88	54.10	54.33	54.55	54.78	55.00	55.23	55.45	55.68	55.90
25	56.13	56.35	56.57	56.80	57.02	57.25	57.47	57.70	57.92	58.15
26	58.37	58.59	58.82	59.04	59.27	59.49	59.72	59.94	60.17	60.39
27	60.62	60.84	61.06	61.29	61.51	61.74	61.96	62.19	62.41	62.64
28	62.86	63.08	63.31	63.53	63.76	63.98	64.21	64.43	64.66	64.88
29	65.11	65.33	65.55	65.78	66.00	66.23	66.45	66.68	66.90	67.13
30	67.35	67.57	67.80	68.02	68.25	68.47	68.70	68.92	69.15	69.37

PLOT RADIUS FACTOR FOR **20** FACTOR (1.944)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	7.78	7.97	8.16	8.36	8.55	8.75	8.94	9.14	9.33	9.53
5	9.72	9.91	10.11	10.30	10.50	10.69	10.89	11.08	11.28	11.47
6	11.66	11.86	12.05	12.25	12.44	12.64	12.83	13.02	13.22	13.41
7	13.61	13.80	14.00	14.19	14.39	14.58	14.77	14.97	15.16	15.36
8	15.55	15.75	15.94	16.14	16.33	16.52	16.72	16.91	17.11	17.30
9	17.50	17.69	17.88	18.08	18.27	18.47	18.66	18.86	19.05	19.25
10	19.44	19.63	19.83	20.02	20.22	20.41	20.61	20.80	21.00	21.19
11	21.38	21.58	21.77	21.97	22.16	22.36	22.55	22.74	22.94	23.13
12	23.33	23.52	23.72	23.91	24.11	24.30	24.49	24.69	24.88	25.08
13	25.27	25.47	25.66	25.86	26.05	26.24	26.44	26.63	26.83	27.02
14	27.22	27.41	27.60	27.80	27.99	28.19	28.38	28.58	28.77	28.97
15	29.16	29.35	29.55	29.74	29.94	30.13	30.33	30.52	30.72	30.91
16	31.10	31.30	31.49	31.69	31.88	32.08	32.27	32.46	32.66	32.85
17	33.05	33.24	33.44	33.63	33.83	34.02	34.21	34.41	34.60	34.80
18	34.99	35.19	35.38	35.58	35.77	35.96	36.16	36.35	36.55	36.74
19	36.94	37.13	37.32	37.52	37.71	37.91	38.10	38.30	38.49	38.69
20	38.88	39.07	39.27	39.46	39.66	39.85	40.05	40.24	40.44	40.63
21	40.82	41.02	41.21	41.41	41.60	41.80	41.99	42.18	42.38	42.57
22	42.77	42.96	43.16	43.35	43.55	43.74	43.93	44.13	44.32	44.52
23	44.71	44.91	45.10	45.30	45.49	45.68	45.88	46.07	46.27	46.46
24	46.66	46.85	47.04	47.24	47.43	47.63	47.82	48.02	48.21	48.41
25	48.60	48.79	48.99	49.18	49.38	49.57	49.77	49.96	50.16	50.35
26	50.54	50.74	50.93	51.13	51.32	51.52	51.71	51.90	52.10	52.29
27	52.49	52.68	52.88	53.07	53.27	53.46	53.65	53.85	54.04	54.24
28	54.43	54.63	54.82	55.02	55.21	55.40	55.60	55.79	55.99	56.18
29	56.38	56.57	56.76	56.96	57.15	57.35	57.54	57.74	57.93	58.13
30	58.32	58.51	58.71	58.90	59.10	59.29	59.49	59.68	59.88	60.07

PLOT RADIUS FACTOR FOR 25 FACTOR (1.739)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	6.96	7.13	7.30	7.48	7.65	7.83	8.00	8.17	8.35	8.52
5	8.70	8.87	9.04	9.22	9.39	9.56	9.74	9.91	10.09	10.26
6	10.43	10.61	10.78	10.96	11.13	11.30	11.48	11.65	11.83	12.00
7	12.17	12.35	12.52	12.69	12.87	13.04	13.22	13.39	13.56	13.74
8	13.91	14.09	14.26	14.43	14.61	14.78	14.96	15.13	15.30	15.48
9	15.65	15.82	16.00	16.17	16.35	16.52	16.69	16.87	17.04	17.22
10	17.39	17.56	17.74	17.91	18.09	18.26	18.43	18.61	18.78	18.96
11	19.13	19.30	19.48	19.65	19.82	20.00	20.17	20.35	20.52	20.69
12	20.87	21.04	21.22	21.39	21.56	21.74	21.91	22.09	22.26	22.43
13	22.61	22.78	22.95	23.13	23.30	23.48	23.65	23.82	24.00	24.17
14	24.35	24.52	24.69	24.87	25.04	25.22	25.39	25.56	25.74	25.91
15	26.09	26.26	26.43	26.61	26.78	26.95	27.13	27.30	27.48	27.65
16	27.82	28.00	28.17	28.35	28.52	28.69	28.87	29.04	29.22	29.39
17	29.56	29.74	29.91	30.08	30.26	30.43	30.61	30.78	30.95	31.13
18	31.30	31.48	31.65	31.82	32.00	32.17	32.35	32.52	32.69	32.87
19	33.04	33.21	33.39	33.56	33.74	33.91	34.08	34.26	34.43	34.61
20	34.78	34.95	35.13	35.30	35.48	35.65	35.82	36.00	36.17	36.35
21	36.52	36.69	36.87	37.04	37.21	37.39	37.56	37.74	37.91	38.08
22	38.26	38.43	38.61	38.78	38.95	39.13	39.30	39.48	39.65	39.82
23	40.00	40.17	40.34	40.52	40.69	40.87	41.04	41.21	41.39	41.56
24	41.74	41.91	42.08	42.26	42.43	42.61	42.78	42.95	43.13	43.30
25	43.48	43.65	43.82	44.00	44.17	44.34	44.52	44.69	44.87	45.04
26	45.21	45.39	45.56	45.74	45.91	46.08	46.26	46.43	46.61	46.78
27	46.95	47.13	47.30	47.47	47.65	47.82	48.00	48.17	48.34	48.52
28	48.69	48.87	49.04	49.21	49.39	49.56	49.74	49.91	50.08	50.26
29	50.43	50.60	50.78	50.95	51.13	51.30	51.47	51.65	51.82	52.00
30	52.17	52.34	52.52	52.69	52.87	53.04	53.21	53.39	53.56	53.74

PLOT RADIUS FACTOR FOR **30** FACTOR (1.588)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	6.35	6.51	6.67	6.83	6.99	7.15	7.30	7.46	7.62	7.78
5	7.94	8.10	8.26	8.42	8.58	8.73	8.89	9.05	9.21	9.37
6	9.53	9.69	9.85	10.00	10.16	10.32	10.48	10.64	10.80	10.96
7	11.12	11.27	11.43	11.59	11.75	11.91	12.07	12.23	12.39	12.55
8	12.70	12.86	13.02	13.18	13.34	13.50	13.66	13.82	13.97	14.13
9	14.29	14.45	14.61	14.77	14.93	15.09	15.24	15.40	15.56	15.72
10	15.88	16.04	16.20	16.36	16.52	16.67	16.83	16.99	17.15	17.31
11	17.47	17.63	17.79	17.94	18.10	18.26	18.42	18.58	18.74	18.90
12	19.06	19.21	19.37	19.53	19.69	19.85	20.01	20.17	20.33	20.49
13	20.64	20.80	20.96	21.12	21.28	21.44	21.60	21.76	21.91	22.07
14	22.23	22.39	22.55	22.71	22.87	23.03	23.18	23.34	23.50	23.66
15	23.82	23.98	24.14	24.30	24.46	24.61	24.77	24.93	25.09	25.25
16	25.41	25.57	25.73	25.88	26.04	26.20	26.36	26.52	26.68	26.84
17	27.00	27.15	27.31	27.47	27.63	27.79	27.95	28.11	28.27	28.43
18	28.58	28.74	28.90	29.06	29.22	29.38	29.54	29.70	29.85	30.01
19	30.17	30.33	30.49	30.65	30.81	30.97	31.12	31.28	31.44	31.60
20	31.76	31.92	32.08	32.24	32.40	32.55	32.71	32.87	33.03	33.19
21	33.35	33.51	33.67	33.82	33.98	34.14	34.30	34.46	34.62	34.78
22	34.94	35.09	35.25	35.41	35.57	35.73	35.89	36.05	36.21	36.37
23	36.52	36.68	36.84	37.00	37.16	37.32	37.48	37.64	37.79	37.95
24	38.11	38.27	38.43	38.59	38.75	38.91	39.06	39.22	39.38	39.54
25	39.70	39.86	40.02	40.18	40.34	40.49	40.65	40.81	40.97	41.13
26	41.29	41.45	41.61	41.76	41.92	42.08	42.24	42.40	42.56	42.72
27	42.88	43.03	43.19	43.35	43.51	43.67	43.83	43.99	44.15	44.31
28	44.46	44.62	44.78	44.94	45.10	45.26	45.42	45.58	45.73	45.89
29	46.05	46.21	46.37	46.53	46.69	46.85	47.00	47.16	47.32	47.48
30	47.64	47.80	47.96	48.12	48.28	48.43	48.59	48.75	48.91	49.07

PLOT RADIUS FACTOR FOR 35 FACTOR (1.47)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	5.88	6.03	6.17	6.32	6.47	6.62	6.76	6.91	7.06	7.20
5	7.35	7.50	7.64	7.79	7.94	8.09	8.23	8.38	8.53	8.67
6	8.82	8.97	9.11	9.26	9.41	9.56	9.70	9.85	10.00	10.14
7	10.29	10.44	10.58	10.73	10.88	11.03	11.17	11.32	11.47	11.61
8	11.76	11.91	12.05	12.20	12.35	12.50	12.64	12.79	12.94	13.08
9	13.23	13.38	13.52	13.67	13.82	13.97	14.11	14.26	14.41	14.55
10	14.70	14.85	14.99	15.14	15.29	15.44	15.58	15.73	15.88	16.02
11	16.17	16.32	16.46	16.61	16.76	16.91	17.05	17.20	17.35	17.49
12	17.64	17.79	17.93	18.08	18.23	18.38	18.52	18.67	18.82	18.96
13	19.11	19.26	19.40	19.55	19.70	19.85	19.99	20.14	20.29	20.43
14	20.58	20.73	20.87	21.02	21.17	21.32	21.46	21.61	21.76	21.90
15	22.05	22.20	22.34	22.49	22.64	22.79	22.93	23.08	23.23	23.37
16	23.52	23.67	23.81	23.96	24.11	24.26	24.40	24.55	24.70	24.84
17	24.99	25.14	25.28	25.43	25.58	25.73	25.87	26.02	26.17	26.31
18	26.46	26.61	26.75	26.90	27.05	27.20	27.34	27.49	27.64	27.78
19	27.93	28.08	28.22	28.37	28.52	28.67	28.81	28.96	29.11	29.25
20	29.40	29.55	29.69	29.84	29.99	30.14	30.28	30.43	30.58	30.72
21	30.87	31.02	31.16	31.31	31.46	31.61	31.75	31.90	32.05	32.19
22	32.34	32.49	32.63	32.78	32.93	33.08	33.22	33.37	33.52	33.66
23	33.81	33.96	34.10	34.25	34.40	34.55	34.69	34.84	34.99	35.13
24	35.28	35.43	35.57	35.72	35.87	36.02	36.16	36.31	36.46	36.60
25	36.75	36.90	37.04	37.19	37.34	37.49	37.63	37.78	37.93	38.07
26	38.22	38.37	38.51	38.66	38.81	38.96	39.10	39.25	39.40	39.54
27	39.69	39.84	39.98	40.13	40.28	40.43	40.57	40.72	40.87	41.01
28	41.16	41.31	41.45	41.60	41.75	41.90	42.04	42.19	42.34	42.48
29	42.63	42.78	42.92	43.07	43.22	43.37	43.51	43.66	43.81	43.95
30	44.10	44.25	44.39	44.54	44.69	44.84	44.98	45.13	45.28	45.42

PLOT RADIUS FACTOR FOR **40** FACTOR (1.375)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	5.50	5.64	5.78	5.91	6.05	6.19	6.33	6.46	6.60	6.74
5	6.88	7.01	7.15	7.29	7.43	7.56	7.70	7.84	7.98	8.11
6	8.25	8.39	8.53	8.66	8.80	8.94	9.08	9.21	9.35	9.49
7	9.63	9.76	9.90	10.04	10.18	10.31	10.45	10.59	10.73	10.86
8	11.00	11.14	11.28	11.41	11.55	11.69	11.83	11.96	12.10	12.24
9	12.38	12.51	12.65	12.79	12.93	13.06	13.20	13.34	13.48	13.61
10	13.75	13.89	14.03	14.16	14.30	14.44	14.58	14.71	14.85	14.99
11	15.13	15.26	15.40	15.54	15.68	15.81	15.95	16.09	16.23	16.36
12	16.50	16.64	16.78	16.91	17.05	17.19	17.33	17.46	17.60	17.74
13	17.88	18.01	18.15	18.29	18.43	18.56	18.70	18.84	18.98	19.11
14	19.25	19.39	19.53	19.66	19.80	19.94	20.08	20.21	20.35	20.49
15	20.63	20.76	20.90	21.04	21.18	21.31	21.45	21.59	21.73	21.86
16	22.00	22.14	22.28	22.41	22.55	22.69	22.83	22.96	23.10	23.24
17	23.38	23.51	23.65	23.79	23.93	24.06	24.20	24.34	24.48	24.61
18	24.75	24.89	25.03	25.16	25.30	25.44	25.58	25.71	25.85	25.99
19	26.13	26.26	26.40	26.54	26.68	26.81	26.95	27.09	27.23	27.36
20	27.50	27.64	27.78	27.91	28.05	28.19	28.33	28.46	28.60	28.74
21	28.88	29.01	29.15	29.29	29.43	29.56	29.70	29.84	29.98	30.11
22	30.25	30.39	30.53	30.66	30.80	30.94	31.08	31.21	31.35	31.49
23	31.63	31.76	31.90	32.04	32.18	32.31	32.45	32.59	32.73	32.86
24	33.00	33.14	33.28	33.41	33.55	33.69	33.83	33.96	34.10	34.24
25	34.38	34.51	34.65	34.79	34.93	35.06	35.20	35.34	35.48	35.61
26	35.75	35.89	36.03	36.16	36.30	36.44	36.58	36.71	36.85	36.99
27	37.13	37.26	37.40	37.54	37.68	37.81	37.95	38.09	38.23	38.36
28	38.50	38.64	38.78	38.91	39.05	39.19	39.33	39.46	39.60	39.74
29	39.88	40.01	40.15	40.29	40.43	40.56	40.70	40.84	40.98	41.11
30	41.25	41.39	41.53	41.66	41.80	41.94	42.08	42.21	42.35	42.49

PLOT RADIUS FACTOR FOR 50 FACTOR (1.230)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	4.92	5.04	5.17	5.29	5.41	5.54	5.66	5.78	5.90	6.03
5	6.15	6.27	6.40	6.52	6.64	6.77	6.89	7.01	7.13	7.26
6	7.38	7.50	7.63	7.75	7.87	8.00	8.12	8.24	8.36	8.49
7	8.61	8.73	8.86	8.98	9.10	9.23	9.35	9.47	9.59	9.72
8	9.84	9.96	10.09	10.21	10.33	10.46	10.58	10.70	10.82	10.95
9	11.07	11.19	11.32	11.44	11.56	11.69	11.81	11.93	12.05	12.18
10	12.30	12.42	12.55	12.67	12.79	12.92	13.04	13.16	13.28	13.41
11	13.53	13.65	13.78	13.90	14.02	14.15	14.27	14.39	14.51	14.64
12	14.76	14.88	15.01	15.13	15.25	15.38	15.50	15.62	15.74	15.87
13	15.99	16.11	16.24	16.36	16.48	16.61	16.73	16.85	16.97	17.10
14	17.22	17.34	17.47	17.59	17.71	17.84	17.96	18.08	18.20	18.33
15	18.45	18.57	18.70	18.82	18.94	19.07	19.19	19.31	19.43	19.56
16	19.68	19.80	19.93	20.05	20.17	20.30	20.42	20.54	20.66	20.79
17	20.91	21.03	21.16	21.28	21.40	21.53	21.65	21.77	21.89	22.02
18	22.14	22.26	22.39	22.51	22.63	22.76	22.88	23.00	23.12	23.25
19	23.37	23.49	23.62	23.74	23.86	23.99	24.11	24.23	24.35	24.48
20	24.60	24.72	24.85	24.97	25.09	25.22	25.34	25.46	25.58	25.71
21	25.83	25.95	26.08	26.20	26.32	26.45	26.57	26.69	26.81	26.94
22	27.06	27.18	27.31	27.43	27.55	27.68	27.80	27.92	28.04	28.17
23	28.29	28.41	28.54	28.66	28.78	28.91	29.03	29.15	29.27	29.40
24	29.52	29.64	29.77	29.89	30.01	30.14	30.26	30.38	30.50	30.63
25	30.75	30.87	31.00	31.12	31.24	31.37	31.49	31.61	31.73	31.86
26	31.98	32.10	32.23	32.35	32.47	32.60	32.72	32.84	32.96	33.09
27	33.21	33.33	33.46	33.58	33.70	33.83	33.95	34.07	34.19	34.32
28	34.44	34.56	34.69	34.81	34.93	35.06	35.18	35.30	35.42	35.55
29	35.67	35.79	35.92	36.04	36.16	36.29	36.41	36.53	36.65	36.78
30	36.90	37.02	37.15	37.27	37.39	37.52	37.64	37.76	37.88	38.01

PLOT RADIUS FACTOR FOR **60** FACTOR (1.123)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	4.49	4.60	4.72	4.83	4.94	5.05	5.17	5.28	5.39	5.50
5	5.62	5.73	5.84	5.95	6.06	6.18	6.29	6.40	6.51	6.63
6	6.74	6.85	6.96	7.07	7.19	7.30	7.41	7.52	7.64	7.75
7	7.86	7.97	8.09	8.20	8.31	8.42	8.53	8.65	8.76	8.87
8	8.98	9.10	9.21	9.32	9.43	9.55	9.66	9.77	9.88	9.99
9	10.11	10.22	10.33	10.44	10.56	10.67	10.78	10.89	11.01	11.12
10	11.23	11.34	11.45	11.57	11.68	11.79	11.90	12.02	12.13	12.24
11	12.35	12.47	12.58	12.69	12.80	12.91	13.03	13.14	13.25	13.36
12	13.48	13.59	13.70	13.81	13.93	14.04	14.15	14.26	14.37	14.49
13	14.60	14.71	14.82	14.94	15.05	15.16	15.27	15.39	15.50	15.61
14	15.72	15.83	15.95	16.06	16.17	16.28	16.40	16.51	16.62	16.73
15	16.85	16.96	17.07	17.18	17.29	17.41	17.52	17.63	17.74	17.86
16	17.97	18.08	18.19	18.30	18.42	18.53	18.64	18.75	18.87	18.98
17	19.09	19.20	19.32	19.43	19.54	19.65	19.76	19.88	19.99	20.10
18	20.21	20.33	20.44	20.55	20.66	20.78	20.89	21.00	21.11	21.22
19	21.34	21.45	21.56	21.67	21.79	21.90	22.01	22.12	22.24	22.35
20	22.46	22.57	22.68	22.80	22.91	23.02	23.13	23.25	23.36	23.47
21	23.58	23.70	23.81	23.92	24.03	24.14	24.26	24.37	24.48	24.59
22	24.71	24.82	24.93	25.04	25.16	25.27	25.38	25.49	25.60	25.72
23	25.83	25.94	26.05	26.17	26.28	26.39	26.50	26.62	26.73	26.84
24	26.95	27.06	27.18	27.29	27.40	27.51	27.63	27.74	27.85	27.96
25	28.08	28.19	28.30	28.41	28.52	28.64	28.75	28.86	28.97	29.09
26	29.20	29.31	29.42	29.53	29.65	29.76	29.87	29.98	30.10	30.21
27	30.32	30.43	30.55	30.66	30.77	30.88	30.99	31.11	31.22	31.33
28	31.44	31.56	31.67	31.78	31.89	32.01	32.12	32.23	32.34	32.45
29	32.57	32.68	32.79	32.90	33.02	33.13	33.24	33.35	33.47	33.58
30	33.69	33.80	33.91	34.03	34.14	34.25	34.36	34.48	34.59	34.70

PLOT RADIUS FACTOR FOR 70 FACTOR (1.039)

DBH	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	4.16	4.26	4.36	4.47	4.57	4.68	4.78	4.88	4.99	5.09
5	5.20	5.30	5.40	5.51	5.61	5.71	5.82	5.92	6.03	6.13
6	6.23	6.34	6.44	6.55	6.65	6.75	6.86	6.96	7.07	7.17
7	7.27	7.38	7.48	7.58	7.69	7.79	7.90	8.00	8.10	8.21
8	8.31	8.42	8.52	8.62	8.73	8.83	8.94	9.04	9.14	9.25
9	9.35	9.45	9.56	9.66	9.77	9.87	9.97	10.08	10.18	10.29
10	10.39	10.49	10.60	10.70	10.81	10.91	11.01	11.12	11.22	11.33
11	11.43	11.53	11.64	11.74	11.84	11.95	12.05	12.16	12.26	12.36
12	12.47	12.57	12.68	12.78	12.88	12.99	13.09	13.20	13.30	13.40
13	13.51	13.61	13.71	13.82	13.92	14.03	14.13	14.23	14.34	14.44
14	14.55	14.65	14.75	14.86	14.96	15.07	15.17	15.27	15.38	15.48
15	15.59	15.69	15.79	15.90	16.00	16.10	16.21	16.31	16.42	16.52
16	16.62	16.73	16.83	16.94	17.04	17.14	17.25	17.35	17.46	17.56
17	17.66	17.77	17.87	17.97	18.08	18.18	18.29	18.39	18.49	18.60
18	18.70	18.81	18.91	19.01	19.12	19.22	19.33	19.43	19.53	19.64
19	19.74	19.84	19.95	20.05	20.16	20.26	20.36	20.47	20.57	20.68
20	20.78	20.88	20.99	21.09	21.20	21.30	21.40	21.51	21.61	21.72
21	21.82	21.92	22.03	22.13	22.23	22.34	22.44	22.55	22.65	22.75
22	22.86	22.96	23.07	23.17	23.27	23.38	23.48	23.59	23.69	23.79
23	23.90	24.00	24.10	24.21	24.31	24.42	24.52	24.62	24.73	24.83
24	24.94	25.04	25.14	25.25	25.35	25.46	25.56	25.66	25.77	25.87
25	25.98	26.08	26.18	26.29	26.39	26.49	26.60	26.70	26.81	26.91
26	27.01	27.12	27.22	27.33	27.43	27.53	27.64	27.74	27.85	27.95
27	28.05	28.16	28.26	28.36	28.47	28.57	28.68	28.78	28.88	28.99
28	29.09	29.20	29.30	29.40	29.51	29.61	29.72	29.82	29.92	30.03
29	30.13	30.23	30.34	30.44	30.55	30.65	30.75	30.86	30.96	31.07
30	31.17	31.27	31.38	31.48	31.59	31.69	31.79	31.90	32.00	32.11

PLOT RADIUS FACTOR FOR **80** FACTOR (0.972)

4	3.89	3.99	4.08	4.18	4.28	4.37	4.47	4.57	4.67	4.76
5	4.86	4.96	5.05	5.15	5.25	5.35	5.44	5.54	5.64	5.73
6	5.83	5.93	6.03	6.12	6.22	6.32	6.42	6.51	6.61	6.71
7	6.80	6.90	7.00	7.10	7.19	7.29	7.39	7.48	7.58	7.68
8	7.78	7.87	7.97	8.07	8.16	8.26	8.36	8.46	8.55	8.65
9	8.75	8.85	8.94	9.04	9.14	9.23	9.33	9.43	9.53	9.62
10	9.72	9.82	9.91	10.01	10.11	10.21	10.30	10.40	10.50	10.59
11	10.69	10.79	10.89	10.98	11.08	11.18	11.28	11.37	11.47	11.57
12	11.66	11.76	11.86	11.96	12.05	12.15	12.25	12.34	12.44	12.54
13	12.64	12.73	12.83	12.93	13.02	13.12	13.22	13.32	13.41	13.51
14	13.61	13.71	13.80	13.90	14.00	14.09	14.19	14.29	14.39	14.48
15	14.58	14.68	14.77	14.87	14.97	15.07	15.16	15.26	15.36	15.45
16	15.55	15.65	15.75	15.84	15.94	16.04	16.14	16.23	16.33	16.43
17	16.52	16.62	16.72	16.82	16.91	17.01	17.11	17.20	17.30	17.40
18	17.50	17.59	17.69	17.79	17.88	17.98	18.08	18.18	18.27	18.37
19	18.47	18.57	18.66	18.76	18.86	18.95	19.05	19.15	19.25	19.34
20	19.44	19.54	19.63	19.73	19.83	19.93	20.02	20.12	20.22	20.31
21	20.41	20.51	20.61	20.70	20.80	20.90	21.00	21.09	21.19	21.29
22	21.38	21.48	21.58	21.68	21.77	21.87	21.97	22.06	22.16	22.26
23	22.36	22.45	22.55	22.65	22.74	22.84	22.94	23.04	23.13	23.23
24	23.33	23.43	23.52	23.62	23.72	23.81	23.91	24.01	24.11	24.20
25	24.30	24.40	24.49	24.59	24.69	24.79	24.88	24.98	25.08	25.17
26	25.27	25.37	25.47	25.56	25.66	25.76	25.86	25.95	26.05	26.15
27	26.24	26.34	26.44	26.54	26.63	26.73	26.83	26.92	27.02	27.12
28	27.22	27.31	27.41	27.51	27.60	27.70	27.80	27.90	27.99	28.09
29	28.19	28.29	28.38	28.48	28.58	28.67	28.77	28.87	28.97	29.06
30	29.16	29.26	29.35	29.45	29.55	29.65	29.74	29.84	29.94	30.03

Appendix D: Recording Plot Information

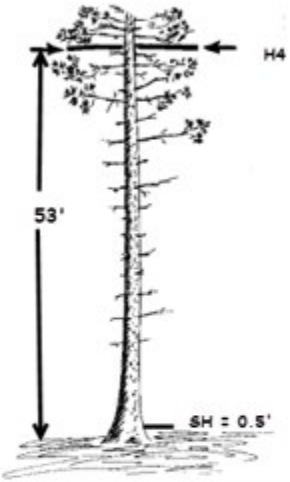
Plot recording procedure:

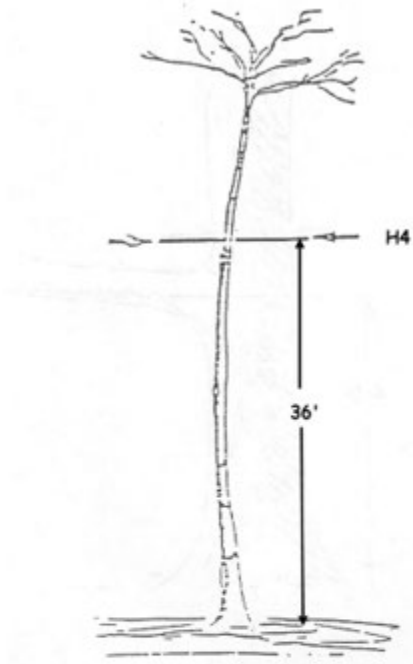
1. Establish plot center with stick or other means (a pin, a flag, etc.)
2. Start cruise at directional compass North.
3. Record the GPS plot location.
4. Flag plot center in the ground and at eye level.
    a. Mark the plot number on flagging.
5. Paint or ribbon the tally trees (optional).

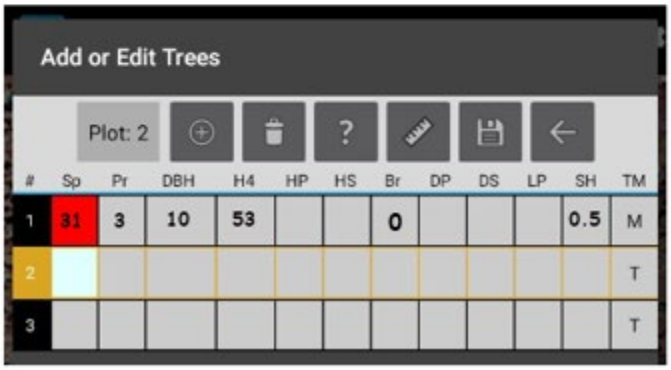
Appendix E: Tree Recording Examples

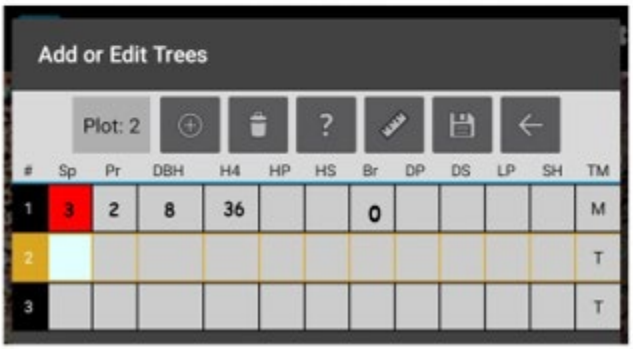
Straight Forward Trees

- **Pulpwood/Undifferentiated Volume (H4)**
    - Heights are always recorded from ground level
    - Stump heights (SH) are defaulted at the cruise level, or recorded at tree level if different than default
    - H4 must contain at least one 8’ (100”) merchantable length, plus stump height
    - Br = 0 (no merchantable wood in branches)







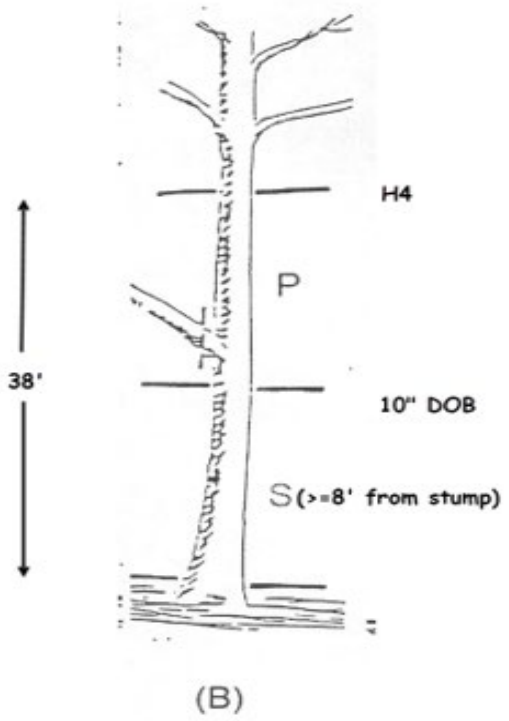


Abbreviation Pr is undifferentiated volume

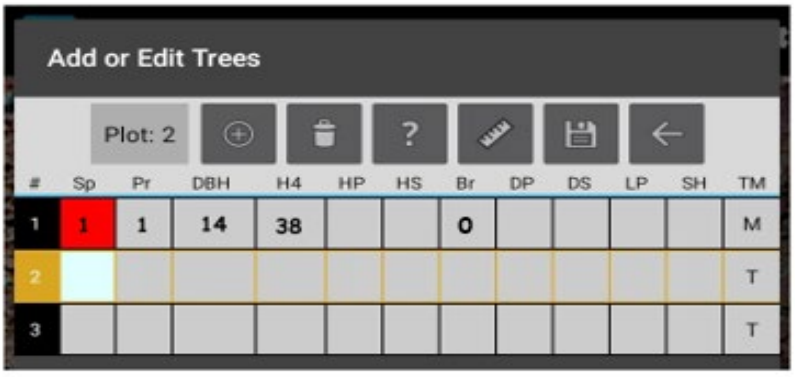
SH is determined at the Cruise level

Straight Forward Trees, continued

- **Sawlogs**
  - Heights are always recorded from ground level
  - Stump heights (SH) are defaulted at the cruise level, or recorded at tree level if different than default
  - H4 must contain at least one 8’ (100”) merchantable length, plus stump height
  - Br = 0 (no merchantable wood in branches)



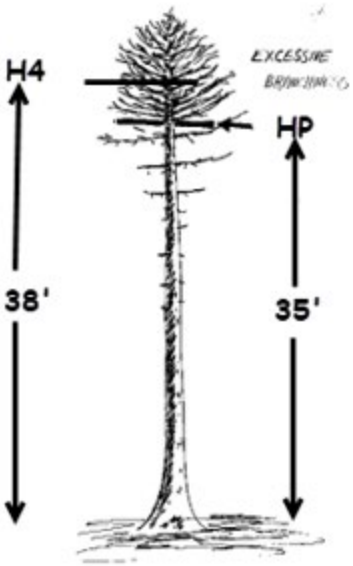
(B)

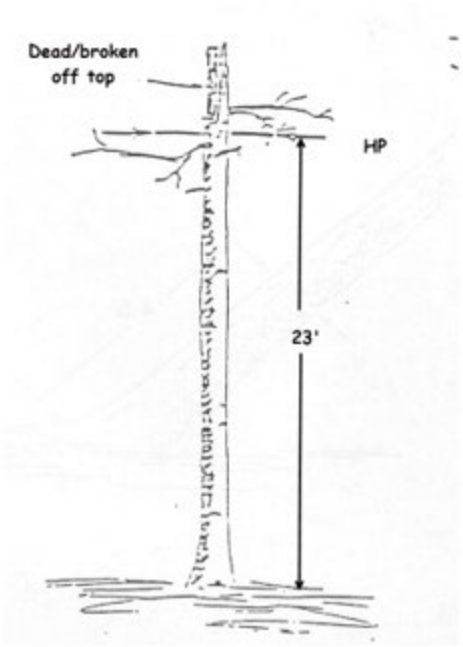


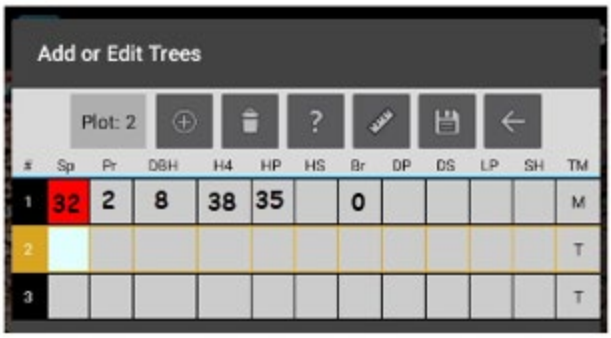
H4 recorded at 4” DOB
Saw volume is calculated by taper model (no need to record saw height if there are no stoppers before 10” DIB).

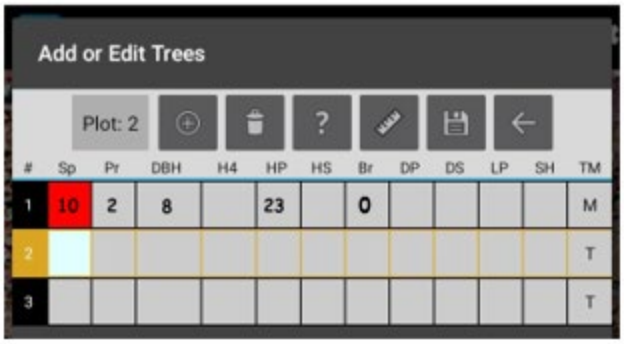
Stoppers

- **Pulpwood/Undifferentiated Volume (HP)**
  - Heights are always recorded from ground level
  - Stump heights (SH) are defaulted at the cruise level, or recorded at tree level if different than default
  - HP must contain at least one 8’ (100”) merchantable length, plus stump height







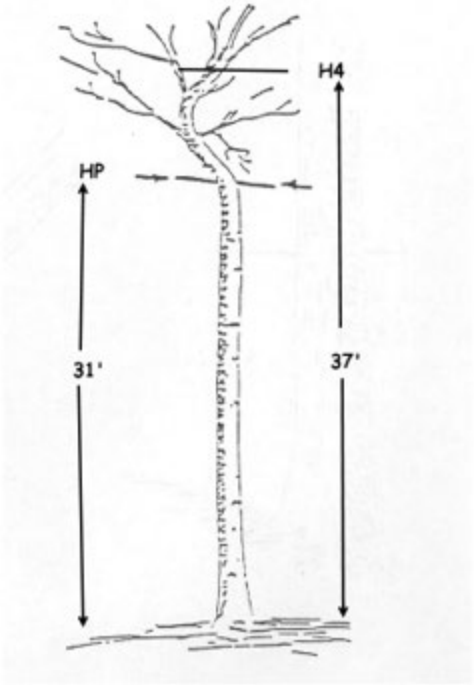


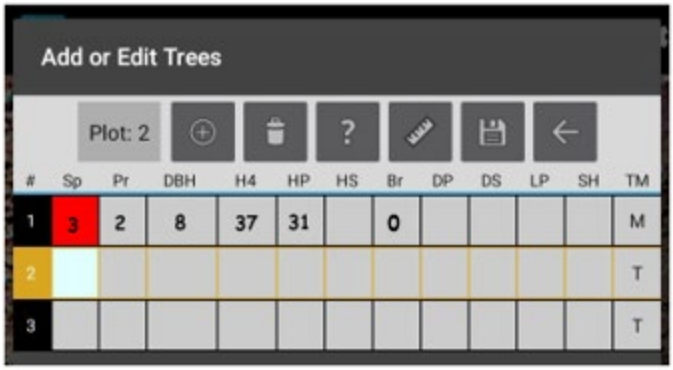
H4 recorded at 4” DOB
HP recorded due to excessive branching
Br = 0 (no merchantable wood in branches

H4 does not exist
HP recorded at stopper
Br = 0 (no merchantable wood in branches)

Stoppers, continued

- **Pulpwood/Undifferentiated Volume (HP), continued**
  - Heights are always recorded from ground level
  - Stump heights (SH) are defaulted at the cruise level, or recorded at tree level if different than default
  - H4 must contain at least one 8’ (100”) merchantable length, plus stump height

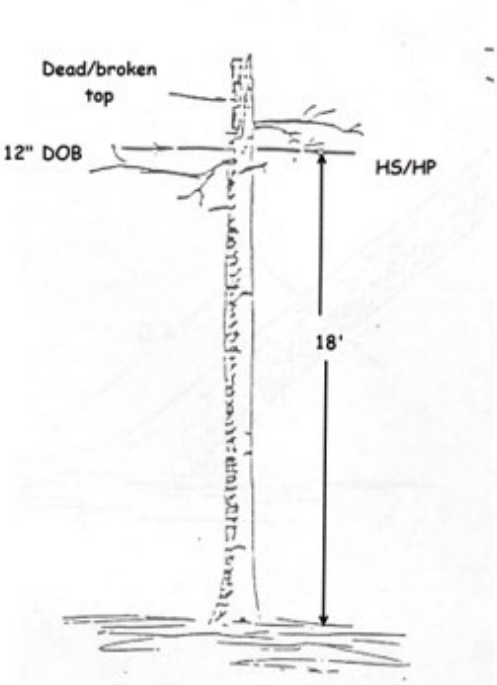


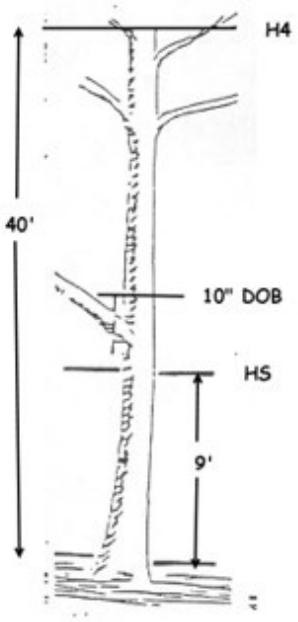


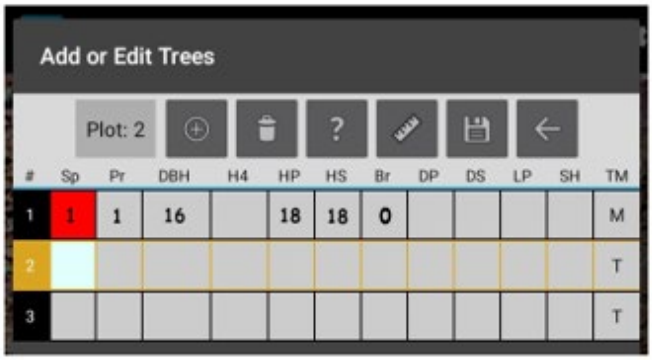
H4 recorded at 4” DOB
HP recorded due to crook
Br = 0 (no merchantable wood in branches)

Stoppers, continued

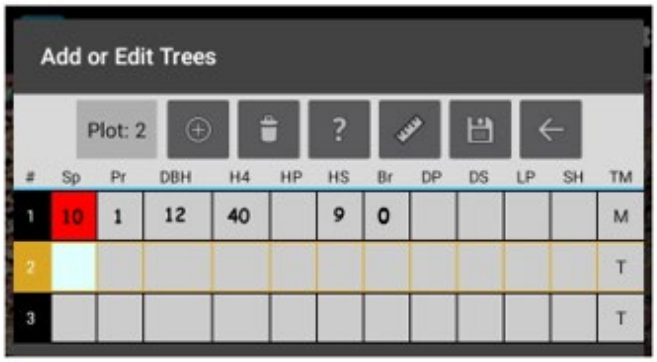
- **Sawlogs (HS)**
  - Heights are always recorded from ground level
  - Stump heights (SH) are defaulted at the cruise level, or recorded at tree level if different than default
  - HS must contain at least one 8’ (100”) merchantable length







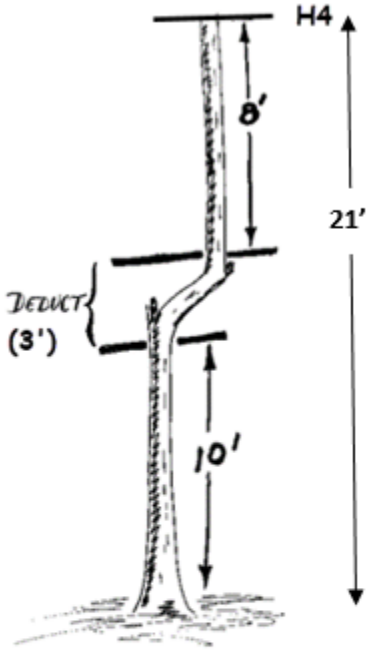
HS = HP; H4 does not exist
Br = 0 (no merchantable wood in branches)

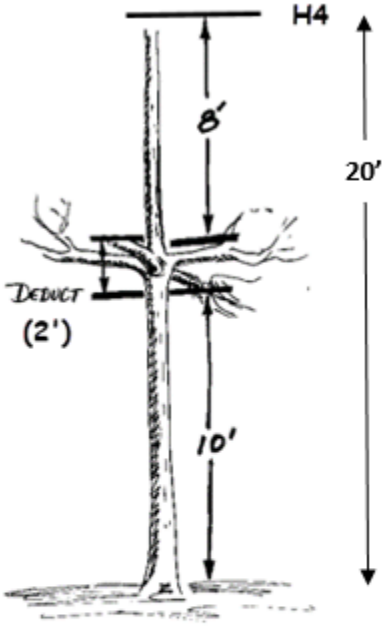


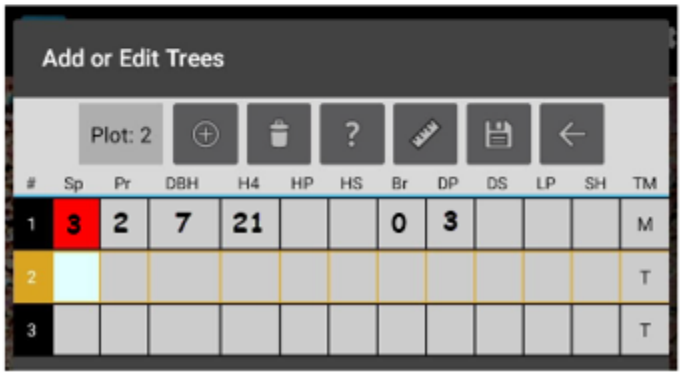
HS recorded – large limb before 10" DOB
Br = 0 (no merchantable wood in branches)

Deduct

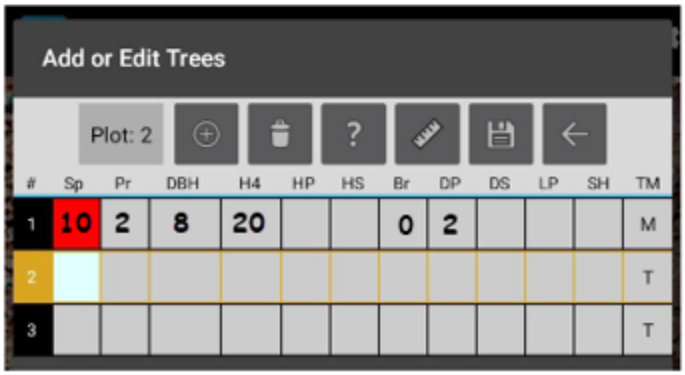
- **Pulpwood (DP)**
  - Deduct is always recorded by its length (in feet)
  - Merchantable lengths above and below deduct must contain at least one 8’ (100”) merchantable length







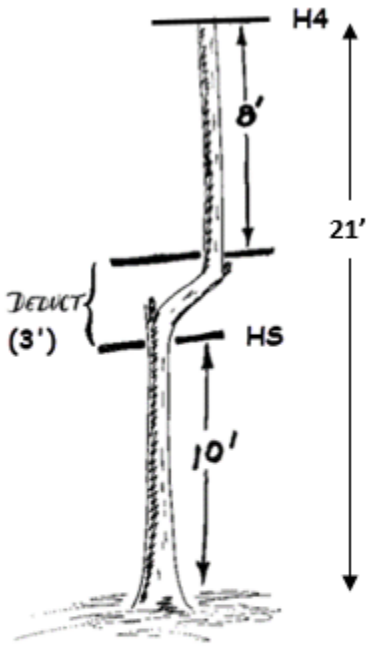
H4 = 10 + 3 + 8 = 21; Deduct Pulp (DP) = 3
Br = 0 (no merchantable wood in branches)

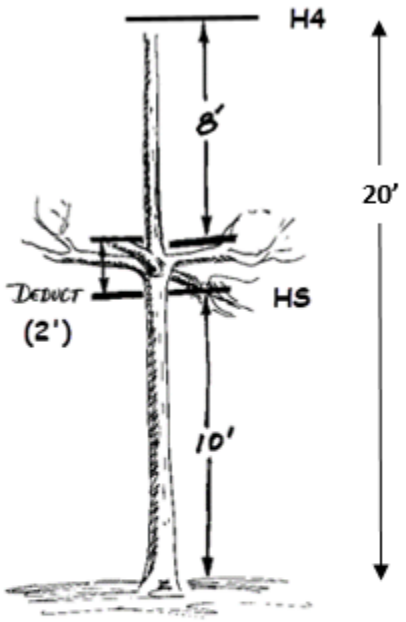


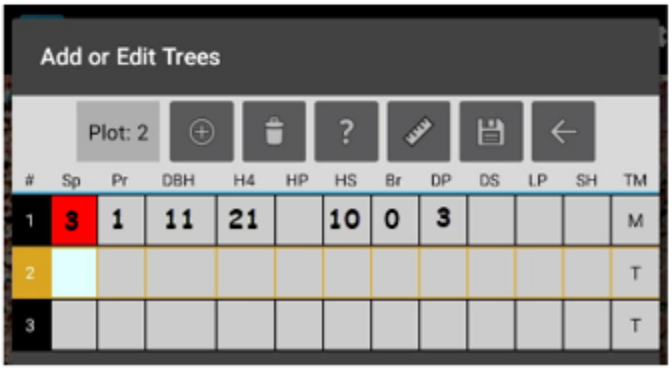
H4 = 10 + 2 + 8 = 20; Deduct Pulp (DP) = 2
Br = 0 (no merchantable wood in branches)

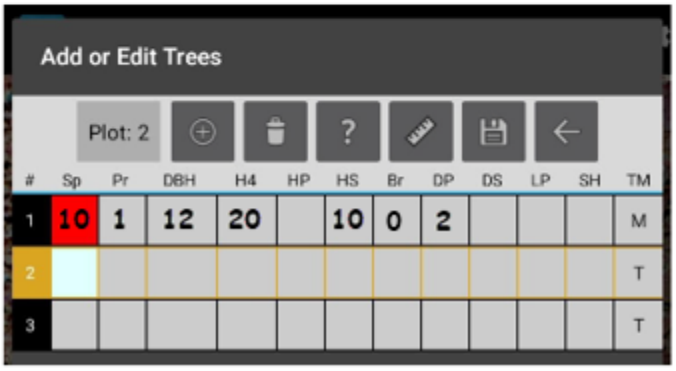
Deduct, continued

- **Sawlogs (DS)**
  - Deduct is always recorded by its length (in feet)
  - Merchantable lengths above and below deduct must contain at least one 8’ (100”) merchantable length







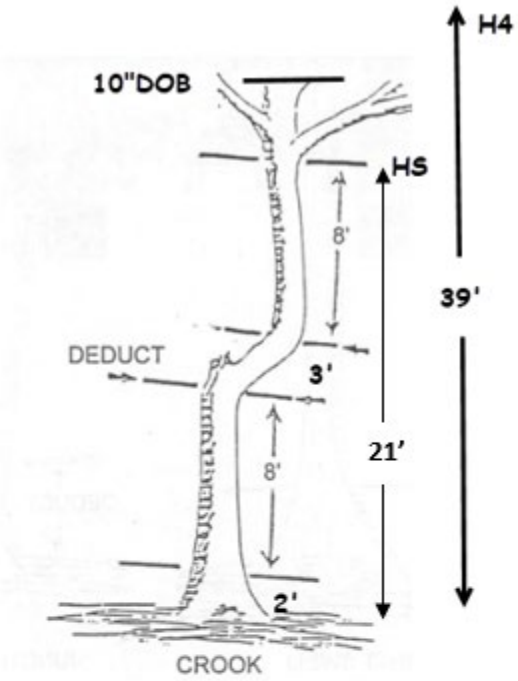


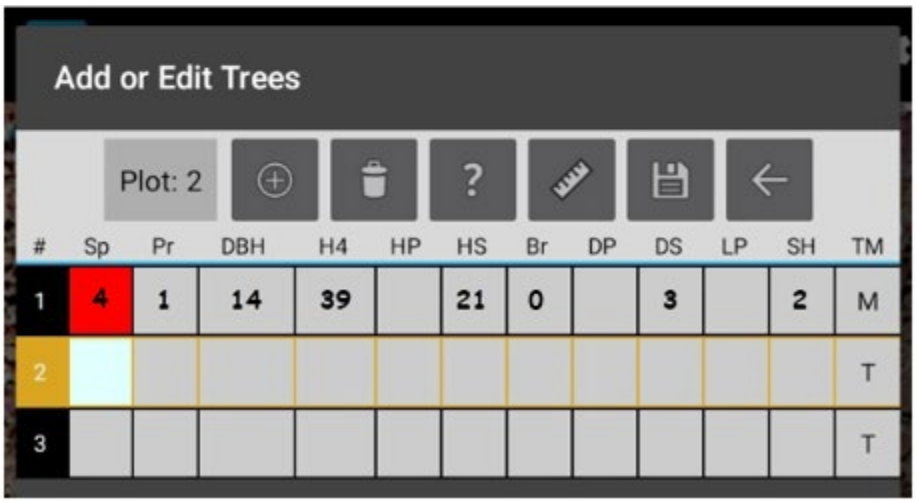
H4 = 10 + 3 + 8 = 21; Deduct Pulp (DP) = 3
Br = 0 (no merchantable wood in branches)

H4 = 10 + 2 + 8 = 20; Deduct Pulp (DP) = 2
Br = 0 (no merchantable wood in branches)

Deduct, continued

- **Sawlogs (DS), continued**
  - Deduct is always recorded by its length (in feet)
  - Merchantable lengths above and below deduct must contain at least one 8’ (100”) merchantable length

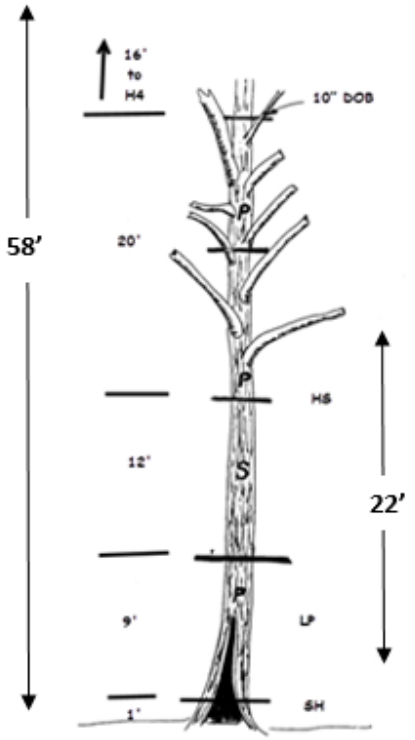




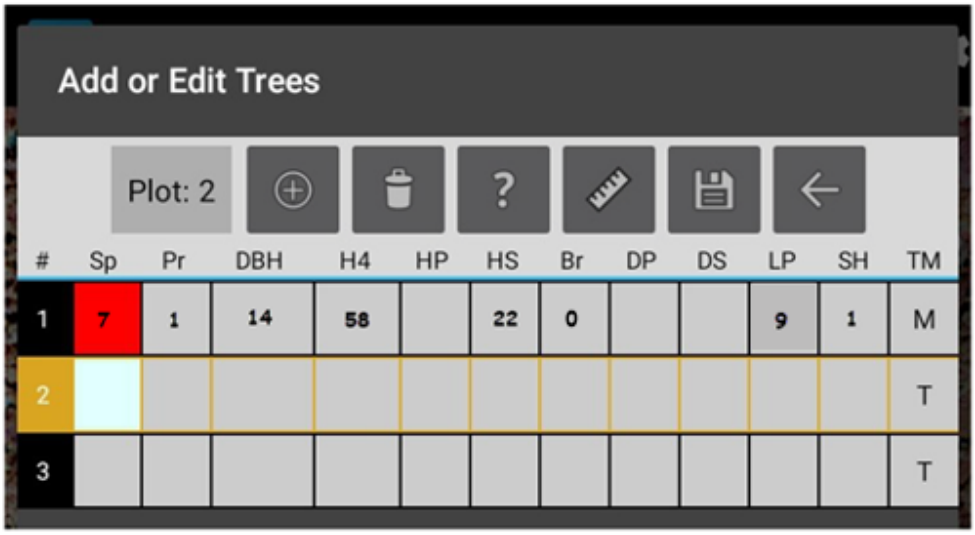
HS = 2 + 8 + 3 + 8 = 21; Deduct Saw (DS) = 3
Br = 0 (no merchantable wood in branches)

Deduct, continued

- **Sawlogs (DS)/Large Pulpwood (LP)**
  - Deduct is always recorded by its length (in feet)
  - Merchantable lengths above and below deduct must contain at least one 8’ (100”) merchantable length



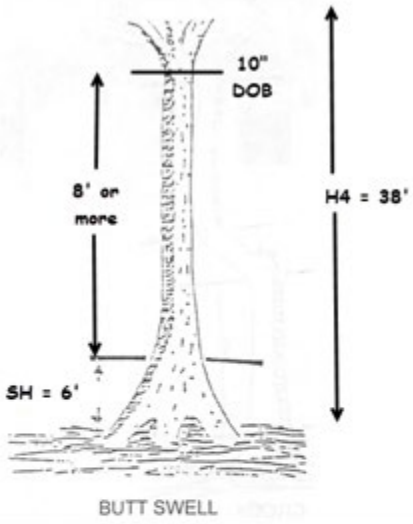
Sawtimber Tally Tree with Large Pulp



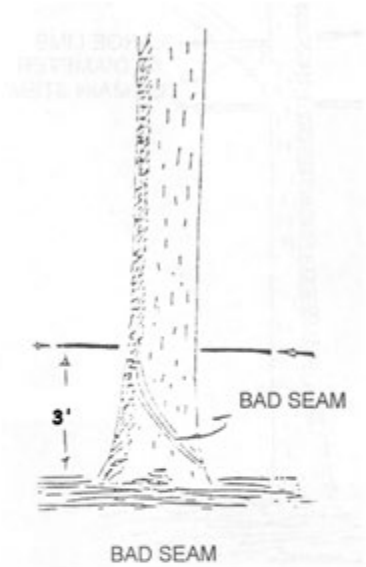
Large Pulp (LP) recorded. Large pulp must be located below a sawlog. LP does not include stump height as it is considered a deduct length. Large pulp must contain at least one 8’ (100”) length.
Pulp above sawlog, even though meets size requirements of saw does not meet merchantability requirements, so will be calculated as pulp in taper model.
Stump Height (SH) recorded if different than default stump height.
Br = 0 (no merchantable wood in branches).

Stump Height (SH)

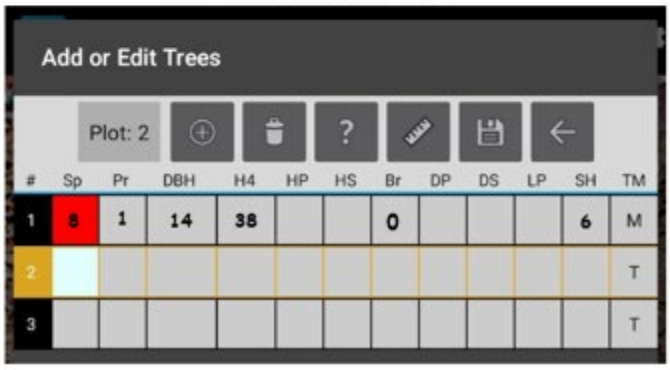
- Need to record if other than default stump height identified at Cruise Level
- Record higher stump height rather than using DP, DS or LP. The taper model will calculate the volume from the ground to the height of the stump, rather than averaging a high and low volume. This provides a better estimate of the deducted volume.



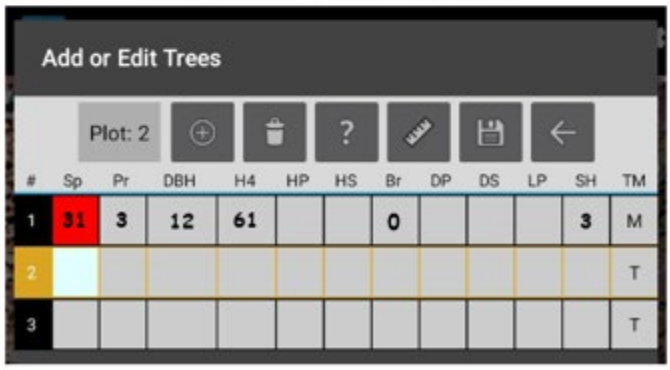
BUTT SWELL



BAD SEAM



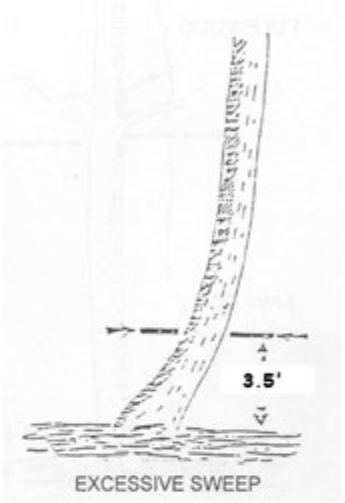
Sawlog (8’ or more) from stump height (SH) to 10” DOB
Br = 0 (no merchantable wood in branches)



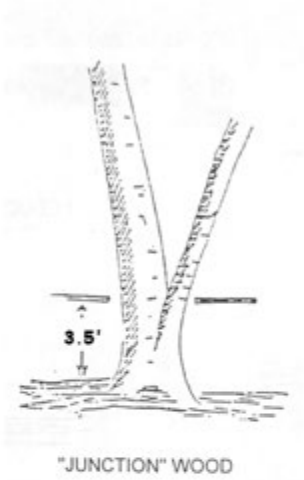
Undifferentiated volume
Br = 0 (no merchantable wood in branches)

Stump Height (SH), continued

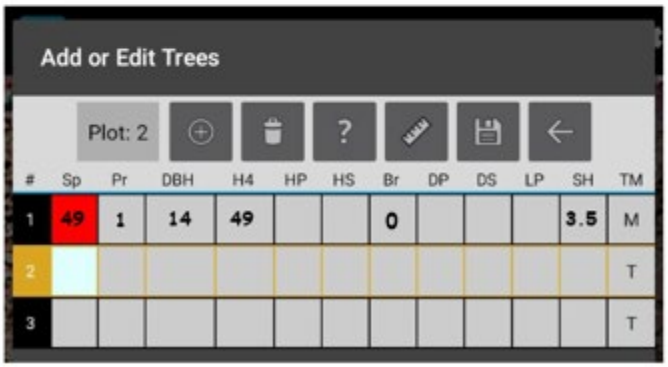
- Need to record if other than default stump height identified at Cruise Level
- Record higher stump height rather than using DP, DS or LP. The taper model will calculate the volume from the ground to the height of the stump, rather than averaging a high and low volume. This provides a better estimate of the deducted volume.



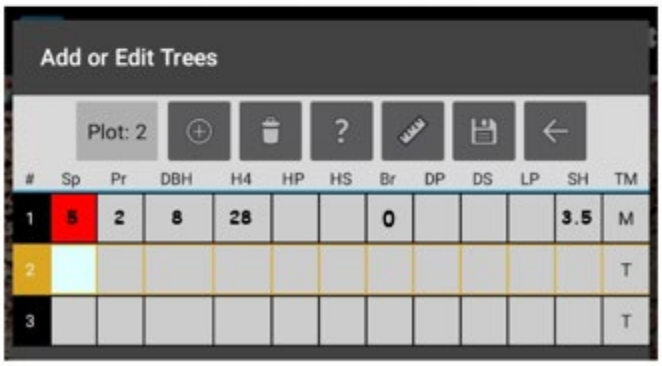
EXCESSIVE SWEEP



"JUNCTION" WOOD



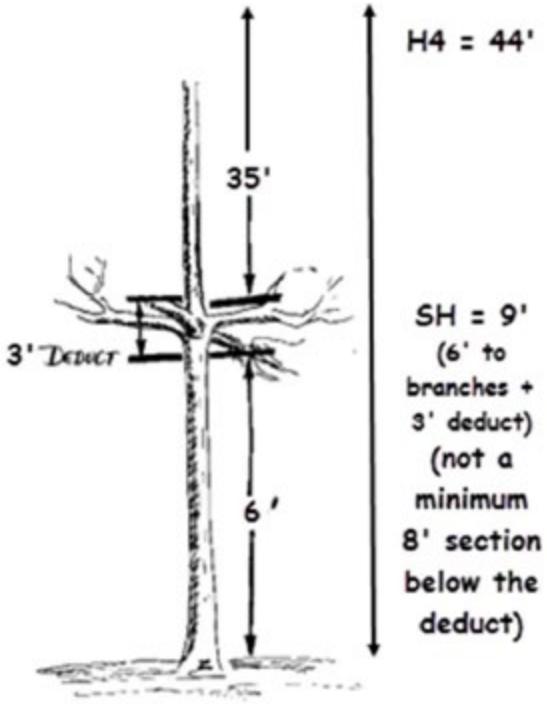
Br = 0 (no merchantable wood in branches)

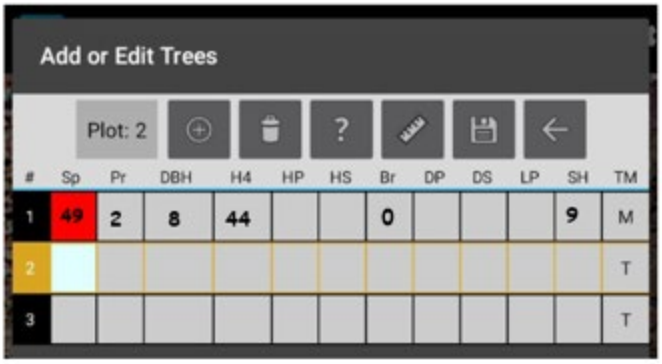


Br = 0 (no merchantable wood in branches)

Stump Height (SH), continued

- Need to record if other than default stump height identified at Cruise Level
- Record higher stump height rather than using DP, DS or LP. The taper model will calculate the volume from the ground to the height of the stump, rather than averaging a high and low volume. This provides a better estimate of the deducted volume.

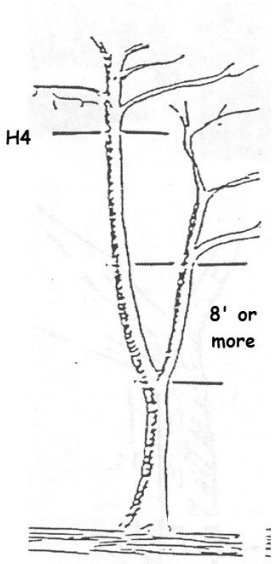


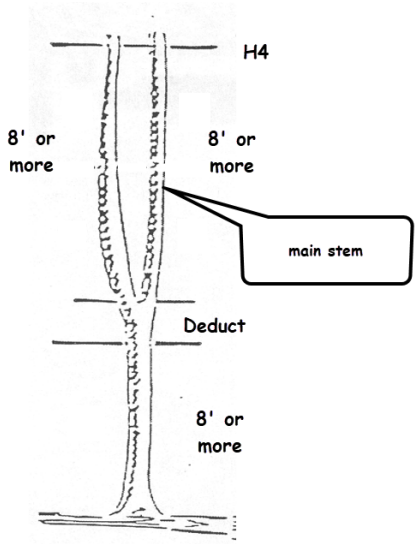


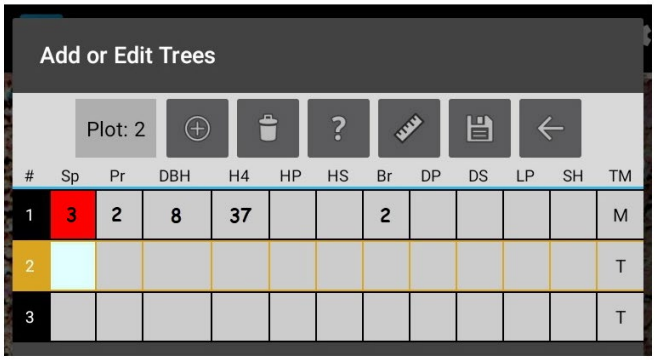
Br = 0 (no merchantable wood in branches)

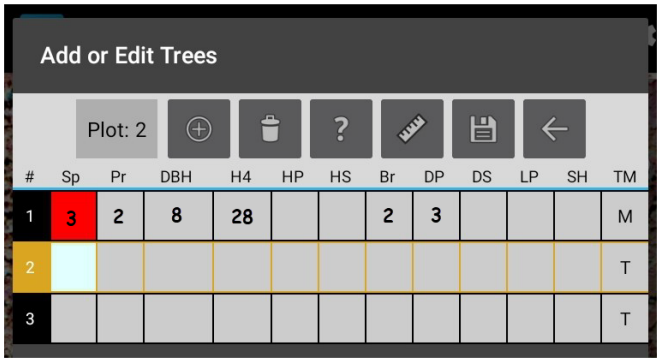
Branches

- **Pulpwood in branches**
  - Br = 2





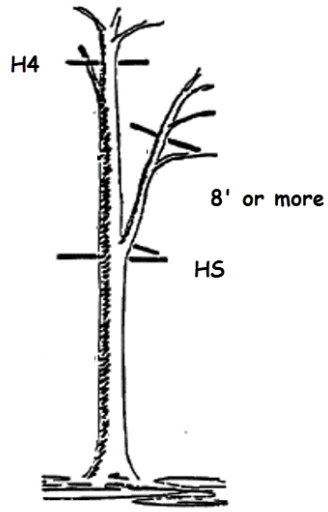


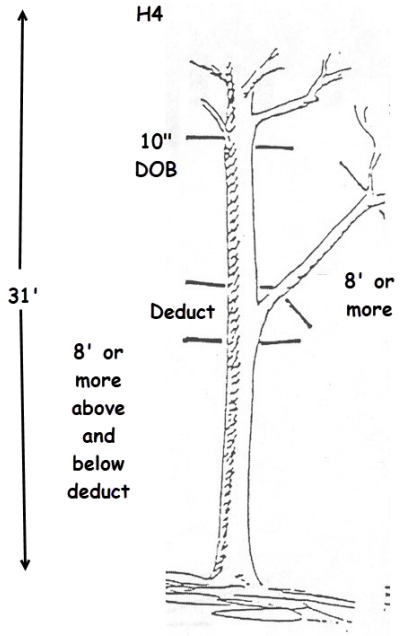


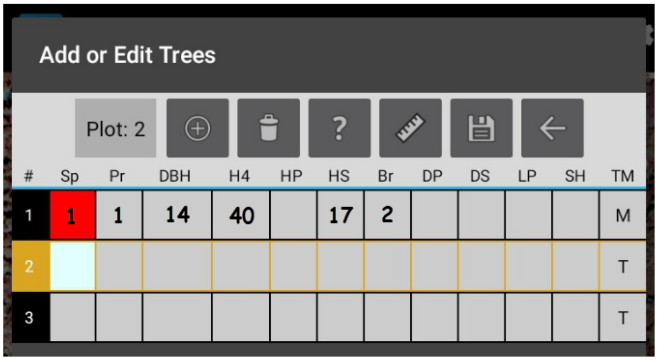
Pulpwood in branch (Br = 2)

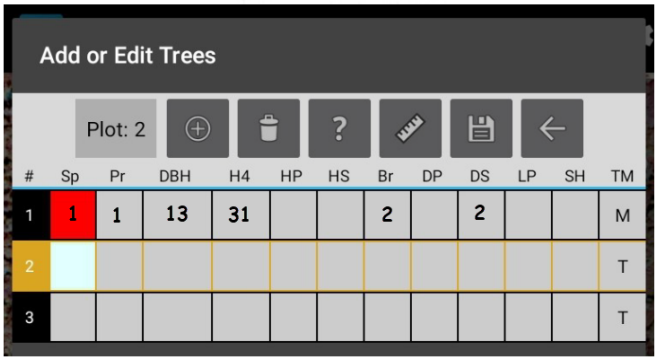
Branches, continued

- **Pulpwood in branches, continued**
  - Br = 2





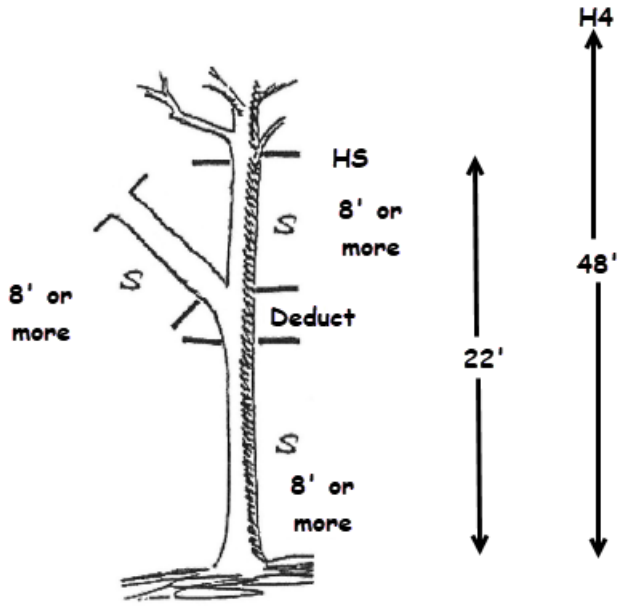


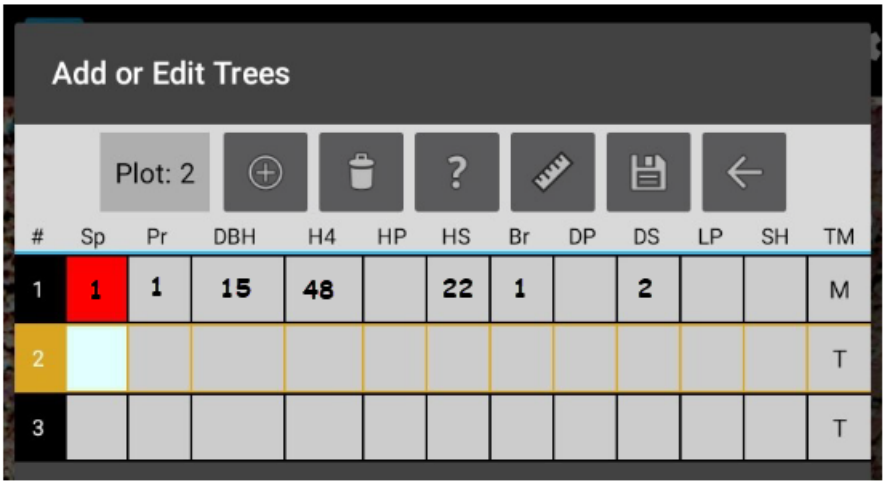


Pulpwood in branches (Br = 2)

Branches, continued

- **Sawlogs in branches**
  - Br = 1

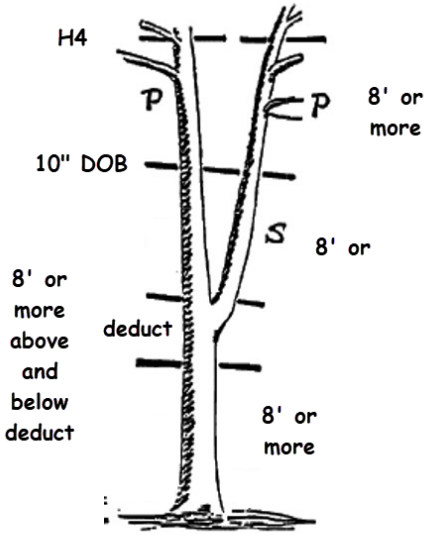


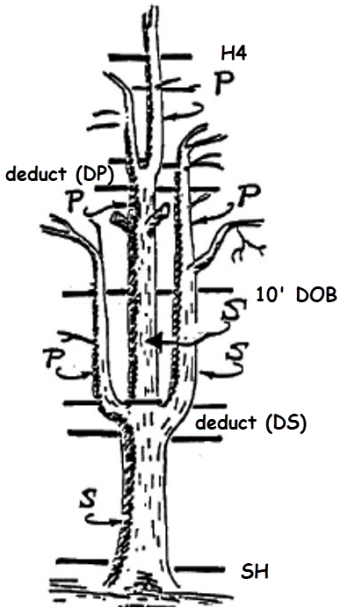


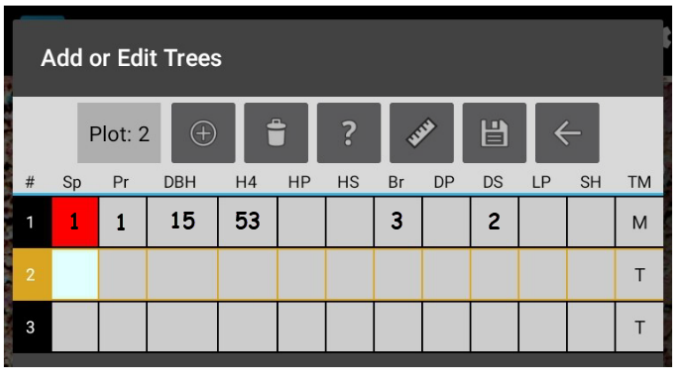
Sawlog in branch(es) (Br = 1)

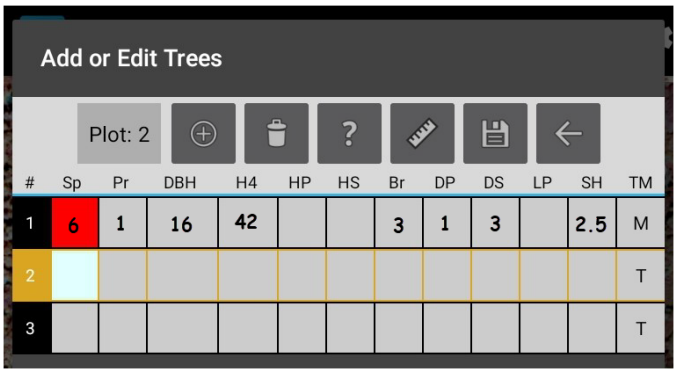
Branches, continued

- **Sawlog and Pulpwood in branches**
  - Br = 3









Sawlog and pulpwood in branch(es) (Br = 3)

- **No merchantable pulpwood or sawlogs in branches**
  - Br = 0