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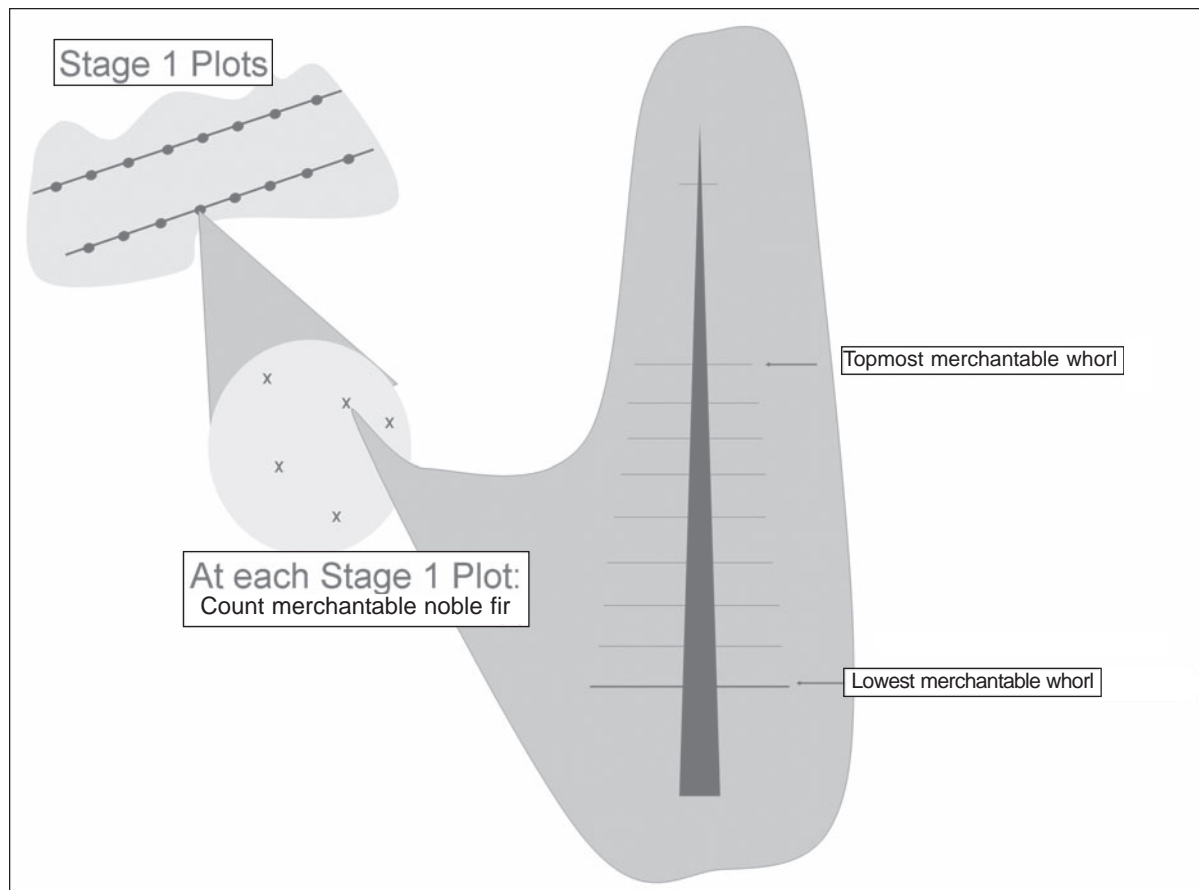
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Users Guide for Noble Fir Bough Cruiser

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William E. Schlosser



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Abstract

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The bough cruiser spreadsheet was developed to provide a method for cruising noble fir (*Abies procera* Rehd.) stands to estimate the weight of boughs that might be harvested. No boughs are cut as part of the cruise process. The approach is based on a two-stage sample. The first stage consists of fixed-radius plots that are used to estimate the number of merchantable noble fir trees per acre. The second stage consists of sample trees that are used to estimate the weight of boughs per tree. The software produces a report with the estimated weight of boughs per tree and per acre.

Keywords: Noble fir, boughs, cruise, sampling, inventory, software.

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Introduction

The bough cruiser spreadsheet was developed to provide a method for cruising noble fir (*Abies procera* Rehd.) stands to estimate the weight of boughs that might be harvested. No boughs are cut as part of the cruise process. The approach is based on a two-stage sample. The first stage consists of fixed-radius plots from one or more transects across a stand. The first-stage plots are used to estimate the number of merchantable noble fir trees per acre. The user chooses the size of this plot and counts the number of merchantable noble fir trees. The second stage consists of sample trees, randomly selected from those located on the first-stage plots, and a count of competing trees from a 20.4-ft-radius plot surrounding each sample tree. The second stage plots and sample trees are used to estimate the weight of boughs per tree. Measurements taken on these trees relate to tree size, age, and number and location of merchantable boughs. Other variables are the number of competing trees on the 20.4-ft plot and geographic location.

The bough cruiser spreadsheet combines field measurements with a bough weight model that was developed from a sample of 322 noble fir trees in the Cascade Mountains of Washington and Oregon. The specific variables used to predict bough weight are total tree height, merchantable bough height, diameter at breast height (DBH) squared, age at breast height, whorl age for each merchantable whorl, the number of merchantable boughs on each whorl, and the total number of trees within a 20.4-ft radius of the plot tree. In addition, an intercept shifter was used that designates noble fir stands located north or south of the Marion/Clackamas County line in Oregon. The overall model was significant at the 0.0001 level with an adjusted R^2 of 0.77 (Blatner and others 2005).

The spreadsheet template, this cruisers guide, and research papers describing the study on which this model is based can all be downloaded from the Pacific Northwest Research Station Web site http://www.fs.fed.us/pnw/data/boughs/boughs_home.htm.

Once the spreadsheet is downloaded, it can be opened by double clicking the file name in the file viewer. The spreadsheet was developed to work with Microsoft™ Excel® 5.0¹ and newer versions. It has not been tested with other spreadsheet software.

¹ The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Overview of Bough Cruiser Spreadsheet

The Bough Cruiser spreadsheet consists of five sheets: instructions, data page, calculator, report, and a tree data entry form. It comes preloaded with data and results for a sample cruise. The instruction sheet has brief instructions for entering data in the spreadsheet and viewing the results. The calculator sheet does intermediate calculations. No user input is required on that sheet. The report sheet (fig. 1) shows the results of a bough cruise. All the information in this sheet is either copied from the data page or calculated by the spreadsheet. The data page (fig. 2) shows the data that are required from the cruise. The data in the tree data entry form are included so that you have the data required to fully replicate the results shown in the users guide. The data can be rearranged into sample plots with a different number of sample trees per plot to test importing data for cruises with different numbers of sample trees.

	A	B	C	D	F	G	H	I
1	Noble Fir Bough Cruiser 1.0							
2	Stand Report							
3	Unit Name:	Sample data			Parcel Size:	10	Acres	
4	Report Date:	5/11/2005			Plot Sample Size:	0.016	Acres	
5	Cruise Date:	6/20/2003			Total Number of Sample Plots:	12		
6	Cruiser's Name:	Smith			Total Number of Measured Trees:	24		
7	Parcel Owner:	USFS			Total Number of Plot Trees:	55		
8								
9			Pounds	Tons	Kilograms	Stumpage Value		
10	Total Green Weight:		75,590 lbs.	37.8 tons	34,359 kg	\$ 11,338		
11	Standard Error:		20,797 lbs.	10.4 tons	9,453 kg	\$ 3,120		
12								
13	Average Green Weight per Acre:		7,559 lbs.	3.8 tons	3,436 kg	\$ 1,134		
14	Standard Error:		2,080 lbs.	1.0 tons	945 kg	\$ 312		
15								
16	Trees Per Acre:		282 TPA	Average Weight per Tree:		26.8 lbs./tree		
17	Standard Error:		55 TPA					
18								
19	Note:	All weights presented in the Bough Cruiser are for boughs with no moisture apparent on them. For weights where there is some moisture present multiply weights by 1.06. For weights where boughs are very wet multiply weights by 1.12. See Blatner et al. 2005 for a discussion of moisture levels and the adjustment procedure.						
20								
21								
22								
23								
24								
25								
26	Comments:							

Figure 1—A sample report from the noble fir bough cruiser.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Noble Fir Bough Cruiser 1.0												
2	Stand [Unit] Identification:			Sample data									
3	N or S of Marion-Clackamas OR co. line:			<input checked="" type="radio"/> North <input type="radio"/> South					Cruiser's Name:		Smith		
4	Unit Size:			10 Acres					Cruise Date:		6/20/2003		
5	Plot Radius:			15.0 Feet		Plot Size:		0.016 Acres			Parcel Owner:		USFS
6	Total Number of Plots:			12					Stumpage Value:		\$0.150		
9	Calculated Green Weight	Plot # .tree #	No. Merch. Noble fir on Plot	DBH	Age	Merchantable Height	Total Tree Height	No. All Trees on 20.4' Plot	Whorl 1 Age	Whorl 1 Boughs	Whorl 2 Age	Whorl 2 Boughs	Whorl 3 Age
11	73.1	1.1	4	30	10.1"	33.0'	50.0'	9	10	6	11	6	12
12	23.9	1.2		26	8.4"	25.0'	44.0'	50	10	6	11	6	12
13		1.3											
14		1.4											
15		1.5											
16	41.8	2.1	4	24	7.9"	31.0'	46.0'	7	10	4	11	4	12
17	36.6	2.2		23	6.9"	29.0'	43.0'	10	10	6	11	6	12
18		2.3											
19		2.4											
20		2.5											
21	99.0	3.1	5	20	10.6"	29.0'	44.0'	5	10	5	11	5	12
22	80.8	3.2		20	11.2"	32.0'	48.0'	4	10	4	11	4	12
23		3.3											
24		3.4											
25		3.5											
26	18.2	4.1	4	20	7.0"	31.0'	46.0'	18	10	3	11	3	12
27	69.3	4.2		17	9.7"	27.0'	40.0'	6	10	4	11	4	12
28		4.3											
29		4.4											
30		4.5											

Figure 2—A portion of the data page with sample data.

Column headings for items in the data page sheet and the tree data entry form are defined in the following tabulation:

Column Heading	Definition
Calculated Green Weight	The estimated green weight in pounds (with no apparent moisture) of boughs for the sample tree. This is calculated by the spreadsheet.
Plot #.tree #	Plots and trees are numbered in sequence by the order they are entered into the cruise program.
No. Merch. Noble Fir on Plot	The number of dominant and codominant noble fir trees with merchantable boughs counted on the plot.
DBH Age	Age at breast height based on counting the whorls from the top of the tree down to breast height.
DBH	Diameter at breast height in inches.
Merchantable Height	The height in feet of the topmost whorl that is to be cut.
Total Tree Height	Total tree height in feet.

No. All Trees on 20.4' Plot	Total number of trees greater than 10 ft tall on 20.4-ft-radius plot around the sample tree, including the sample tree.
Whorl 1 Age	Age of the topmost merchantable whorl based on counting the whorls from the top of the tree to the topmost merchantable whorl.
Whorl 1 Boughs	The number of merchantable boughs to be cut from the topmost merchantable whorl.
Whorl 2 to 15 Age	Age of subsequent merchantable whorls.
Whorl 2 to 15 Boughs	Number of merchantable boughs to be cut from subsequent whorls.

Figure 3 illustrates the process for determining some of the values described in the above tabulation. There are 17 whorls counting down from the top to breast height making DBH age 17 years. Merchantable height is between whorl 9 and 10 making whorl 10 the first merchantable whorl and 10 years the age of merchantable whorl 1. The ages of merchantable whorls 2 through 8 are 11 to 17 years. The process may extend below breast height if there are additional merchantable boughs below breast height. A whorl within the merchantable range should be skipped if it does not have at least two merchantable boughs on it.

Conducting the Bough Cruise

An Example

The following example of a bough cruise provides an overview of the process. A 10-ac unit of noble fir was cruised. First-stage plots were located 125 ft apart on two transects across the long dimension of the unit and resulted in 12 stage-one plots. A plot radius of 15 ft was used, and the desired number of stage-two sample trees was two. There were four merchantable noble fir trees on the first plot. Two of them were randomly selected for the stage-two sample. Measurements were taken and recorded to provide values for each of the variables described in the tabulation above. The process was continued on each of the remaining stage-one plots. A portion of the data resulting from the cruise is shown in figure 2. The tree measurements in this example are from trees that were measured to estimate the bough weight model (Blatner and others 2005). The numbers of noble fir on stage-one plots and the assignment of the measured trees to plots were made up to create this example.

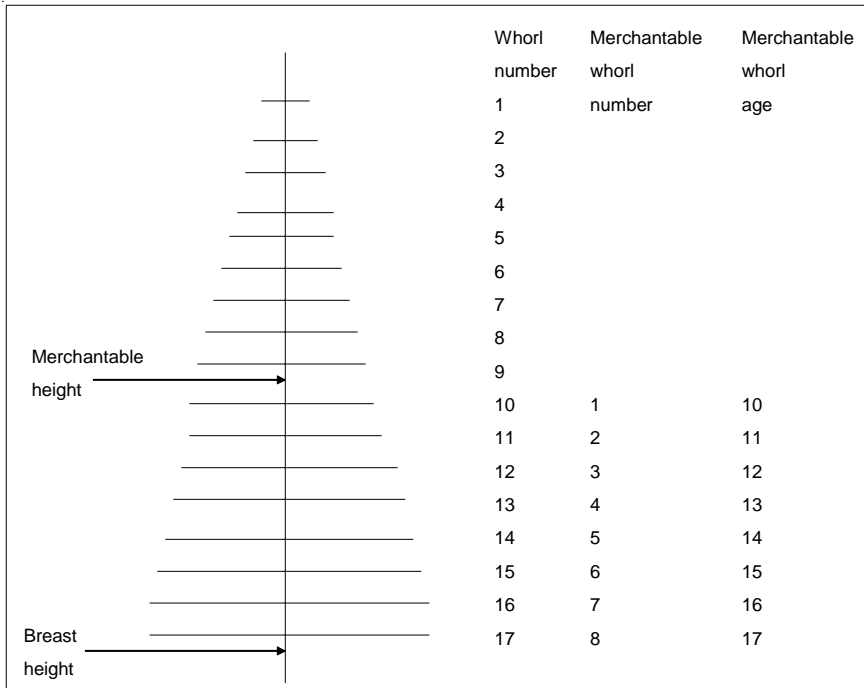


Figure 3—Diagram illustrating the numbering of whorls, merchantable whorls, and whorl age for merchantable whorls.

Sample Design

The Noble Fir Bough Cruiser spreadsheet was designed to be used with two-stage cluster sampling.² Stage one is used to get an unbiased estimate of the number of merchantable noble fir trees in the unit. It uses a fixed-radius plot with the radius chosen by the user. The radius should be set so that most plots will have at least the number of trees desired for the stage-two sample and small enough to keep the cost of counting the number of merchantable trees reasonable. Stage two is the measurement of one or more merchantable noble fir trees located on each stage-one plot. Merchantable trees are defined as having at least two not-previously-harvested merchantable whorls up to the merchantable height. The cruiser calculations and input process assumes that the cruise design calls for all of the plots to have the same number of sample trees. It is acceptable, however, to have a lesser number or even zero sample trees on the occasional plot that is located where there are not enough nobles on the plot to get the desired number of stage-two sample trees.

² Chapman, R.C.; Blatner, K.A.; Schlosser, W.E.; Fight, R.D. [N.d.]. A sampling method for inventorying noble fir stands to determine merchantable bough weight. Manuscript in preparation. On file with: Roger C. Chapman, Department of Natural Resource Sciences, P.O. Box 646410, Washington State University, Pullman, WA 99164.

The variables listed in the input form and their definitions in the above tabulation provide a description of the data that needs to be collected in the bough cruise. The issues that need further elaboration are the methods for selecting the number and location of plots and the sample trees. Chapman and others (n.d.) provide a discussion of how to determine the number of plots and the number of sample trees per plot (see footnote 2). The number of plots and sample trees per plot depend on the desired accuracy, the available budget, the relative cost of measuring plots and sample trees, and the relative variance between plots and within plots. A minimum of two sample trees per plot are required to compute error terms for the sample. Figure 4 adapted from Chapman and others suggests that two sample trees per plot will often be a good choice. Between-plot and within-plot variance for completed cruises can be viewed on the calculator sheet at cells J4 and J5. This may be helpful in deciding how many sample trees to select per plot on future cruises.

Once the number of plots and the number of sample trees per plot have been determined, field procedures need to be addressed. An easy way to locate the required number of plots is to use one or more transects through the stand being cruised. The estimated total length of transect divided by the number of plots provides the distance between plots along the transect. Follow the transect to the first plot. Using the plot radius that you have chosen, count the number of merchantable noble fir trees on the plot. Randomly select the number of sample nobles

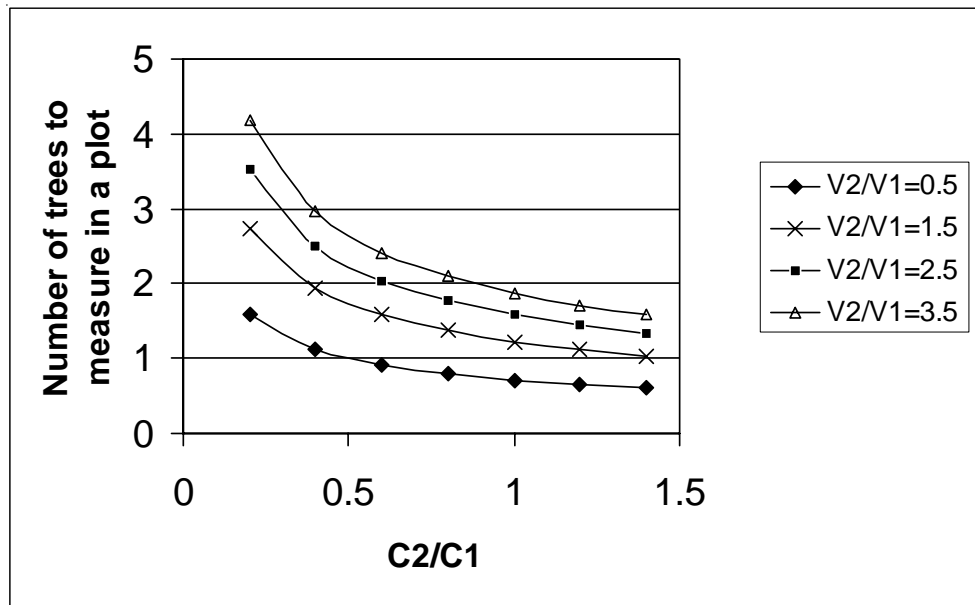


Figure 4—The most efficient number of stage-two sample trees per plot for a range of ratios of between-plot and within-plot variance ($V2/V1$) and a range of ratios of measurement cost per sample tree to the cost to establish and measure stage-one plots ($C2/C1$).

called for in the cruise. Measure and record the following tree measurements for each sample tree: DBH age, DBH, merchantable height, and the whorl data for whorls to be cut. Also count the total number of trees taller than 10 ft on the 20.4-ft-radius plot surrounding each sample tree. Go back to the transect and move along the transect to the next plot and repeat the process until all plots and sample trees have been measured and recorded.

Completing the Cruise Estimates

Once data collection is complete, the data need to be entered into the data page. The data at the top of the data page are entered item by item. These data are used in calculating the results and therefore must be entered before results can be viewed. The tree data in the lower part can be entered item by item, but the tree data from a bough cruise can also be imported in a block by use of the tree data entry form. Data in spreadsheet format can be copied and pasted into the tree data entry form and then imported into the data page by use of the import data macro located on the toolbar. This will generally be the easiest way to enter the data from a bough cruise into the bough cruiser spreadsheet. Choose the data import macro that corresponds to the number of sample trees per plot in stage two of your sample. For illustrative purposes in this users guide, we assumed that the sample was conducted on one or more transects through a single stand and the number of sample trees desired per plot was two.

The bough cruiser spreadsheet recalculates with each data entry, so once all data have been entered in the data page, the results are ready to view in the report sheet. The report sheet has an area where notes can be added. This is a good place to document information that will be useful in writing the specifications for a bough sale or instructions for harvesters. The report sheet is designed to be printed to create a standard report for the estimated volume of boughs to be cut from a unit.

This sampling scheme does not take into account some things that may affect the actual yield of boughs. Broken terrain, steep slopes, pockets of low concentration of merchantable boughs, or long distances between parts of the unit and the bough pickup point may result in parts of the unit being bypassed by harvesters because the effort is too great. Because boughs are a relatively low-valued product, it would not be cost effective to develop a sampling scheme that would account for

these factors. Making a separate estimate of the proportion that might be impractical to harvest and providing that information along with the cruise estimate is a reasonable way of providing the full disclosure that bidders need to make bids that accurately reflect the value of the boughs.

Metric Equivalents

When you know:	Multiply by:	To find:
Feet (ft)	.3048	Meters
Acres (ac)	.405	Hectares

Literature Cited

Blatner, K.A.; Fight, R.D.; Vance, N.; Savage, M.; Chapman, R.C. 2005. A model to estimate noble fir bough weight. *Western Journal of Applied Forestry*. 20(1): 44-49.

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