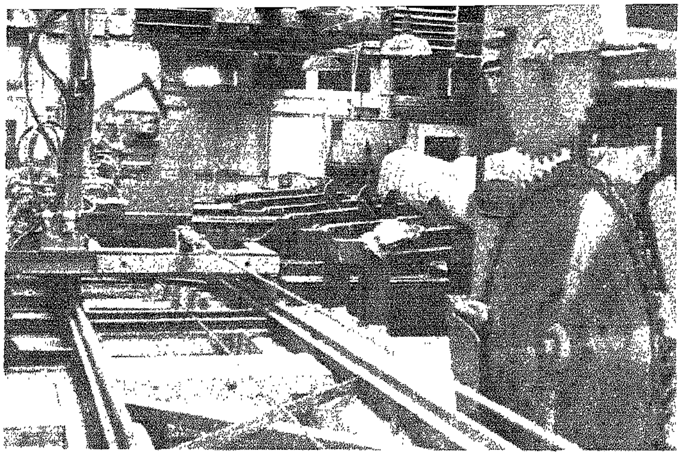
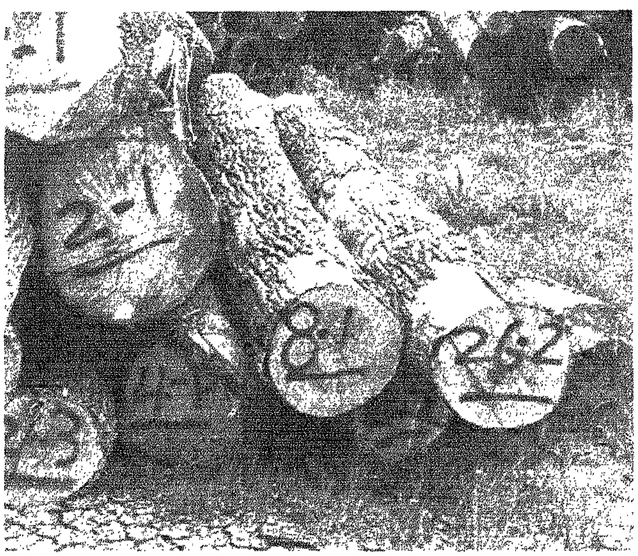


by Leland F. Hanks

How to Predict Lumber-Grade Yields for Graded Trees



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INTERESTED?

If you are interested in developing lumber-grade yields for your sawmill, and have questions about field procedure or analysis, please contact Project 3102, Northeastern Forest Experiment Station, P.O. Box 365, Delaware, Ohio 43015.

How to Predict Lumber-Grade Yields for Graded Trees

ABSTRACT

A procedure is shown for developing lumber-grade yields to be used with the USDA Forest Service Hardwood Tree Grades for Factory Lumber. Yield development is followed from the time of selecting trees, through sawing the logs and grading the lumber, to the development of predicted lumber grade yields. By following this procedure, a sawmill operator can develop yields that are representative of both his sawmill and the local timber.

IN OUR RESEARCH with hardwood tree grades, we have developed a procedure that the sawmill owner can use to develop lumber-grade yields for his own sawmill. This procedure may also be useful to consulting foresters and state and federal utilization specialists.

Hardwood tree grades and lumber-grade yields are now available for 11 species: yellow birch, paper birch, sugar maple, red maple, yellow-poplar, basswood, black cherry, northern red oak, black oak, white oak, and chestnut oak (*Hanks 1976b*).

In our field trials of the USDA Forest Service Hardwood Tree Grades for Factory Lumber, we have shown that the tree grades can be used to separate groups of trees into grades that have meaningful value differences (*Hanks 1976a*). These trials also showed that total tree lumber volume and value can be predicted by using the lumber-grade yields.

For groups of about 50 trees, the differences between actual and predicted lumber volumes generally ranged from 2 to 9 percent, while differences for lumber value generally ranged from 2 to 14 percent. These differences occurred because volume and value-controlling factors such as tree form and interior cull are not consistent within a species. Sawmill equipment, sawing practices, and markets also affected the volume and value of lumber produced during the field trials and during the studies conducted when the lumber-grade yields were being developed.

To lessen the effects of variation due to sawmill practices and the nature of the timber sawed, a sawmill operator can determine lumber-grade yields specific to his mill and the timber he handles. He may also want to determine yields and values of species for which yield information is unavailable.

This guide outlines a procedure for developing lumber-grade yields to be used with the existing hardwood tree grades.

If an operator is not interested in lumber-grade yields, but needs to know only total value and volume of lumber expected from graded trees, we have a procedure that he can use.

To make full use of this guide, a sawmill operator must deal with standing trees that are graded. Access to data-processing equipment, including a computer, is assumed.

Development of Lumber-grade Yields

Field Procedure

The first step is to establish the available range in dbh (diameter at breast height) and merchantable height. This information could come from recent inventory or appraisal records.

Then, for the species involved, select *approximately 60 trees per tree grade* that cover the established range in sizes. When choosing trees, it is best to eliminate non-typical trees—trees that fork, trees that are outside the range of sizes normally encountered, and trees that have excessive defect outside the grading section. Of course, such trees do exist, and at a later time you will be required to appraise them. For further discussion of this, see the appendix.

At the time of tree selection, measure both dbh and merchantable height. Record dbh to the nearest inch and merchantable height to the nearest foot. Also record tree grade, and assign a number to each tree (fig. 1).

After felling, the trees should be bucked, and each log should be numbered for future identification. We suggest that the number be composed of the tree number followed by the log position within the tree; for example, the second log from the fifth tree would be tree-log No. 05-2 (fig. 2). Study logs should be decked together on the mill yard in preparation for sawing (fig. 3).

Species ______________ Date ______________________

Comments: ____________________________ Recorder __________________

TREE NUMBER	D.B.H.	MERCHANTABLE HEIGHT	TREE GRADE	TREE NUMBER	D.B.H.	MERCHANTABLE HEIGHT	TREE GRADE

Figure 1.—Suggested form for recording tree information.

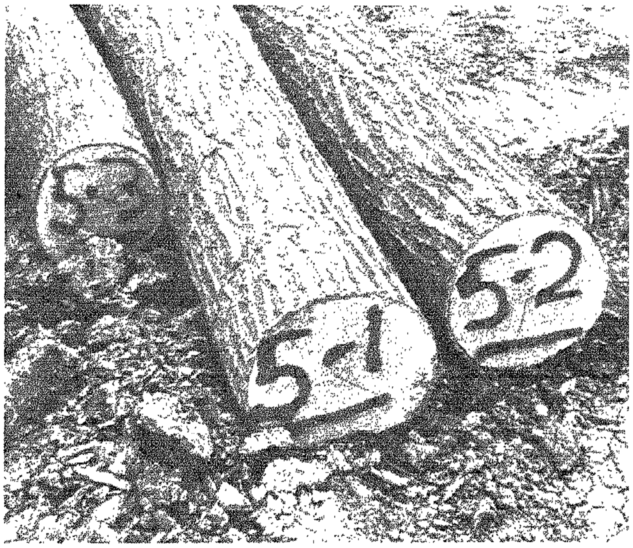

Figure 2.—Logs from tree number 5.

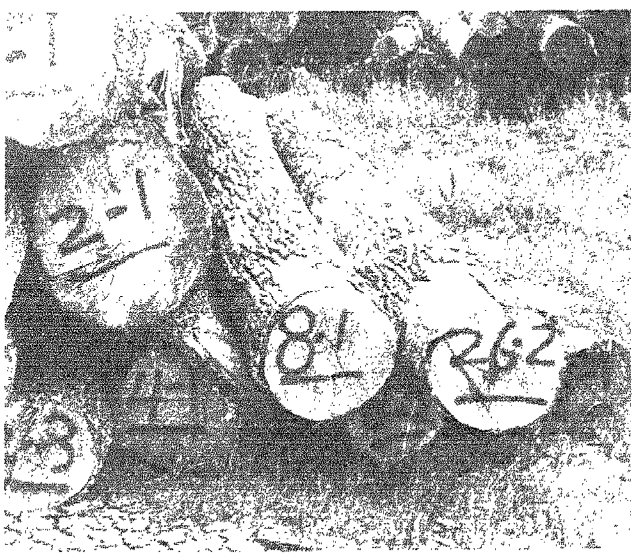

Figure 3.—Study logs decked before sawing.

Mill Procedure

The sawmill equipment should be put in top-notch condition before sawing, and the study crew should be carefully instructed as to their assignments. The lumber thickness pattern and both edging and trimming practices should be comparable with what is considered normal for the sawmill.

Our suggested numbering procedure is to assign consecutive numbers to the logs as they are sawed. The first log sawed becomes log number 1, the second log becomes log number 2, etc. These so-called sawing-order numbers differ from the previously assigned tree-log numbers. Therefore, a person should be stationed near the log deck to record the tree-log number and the sawing-order number of each log (figs. 4 and 5).

Each board from a log must be numbered with the sawing-order number (fig. 6). In other words, every board from the first log sawed must contain the number 1, etc. We have learned that, with a sequential numbering system, the numbering crew is less likely to make mistakes.

The mill layout and sawing procedure determine how many people are required for numbering boards. Any time a board is cut in two, someone must number the unnumbered piece. A typical situation will be one or two men for both the edger and trim saws and one or two men for the unedged boards. They all must know what number to apply to an unnumbered board passing their stations. The man at the trim saw can usually obtain the correct number from an adjoining piece (fig. 7), while men at the other positions can often read the sawing-order number from the end of the log (applied with chalk just before sawing). If these men cannot see the log, some sort of communication must be arranged between them and the area near the headsaw. Hand signals, blackboard, and flip cards have been used successfully. Color codes have been used in mills that do not make use of a resaw.

If a resaw is used, and cants are allowed to accumulate, special care must be taken to assure proper numbering of each board.

Black lumber keel is recommended for numbering boards.

Lumber Grading Procedure

If the sawmill operator is interested in green lumber grade yields, the lumber should be measured and graded as soon as possible. Grading on the green chain will probably not be satisfactory because the noise levels are pecies ____________ Date ____________

ill ____________ Recorder ____________

SAWING ORDER NUMBER	TREE LOG NUMBER	SAWING ORDER NUMBER	TREE LOG NUMBER	SAWING ORDER NUMBER	TREE LOG NUMBER

Figure 4.—Suggested form for recording sawing sequence of tree-log numbers.

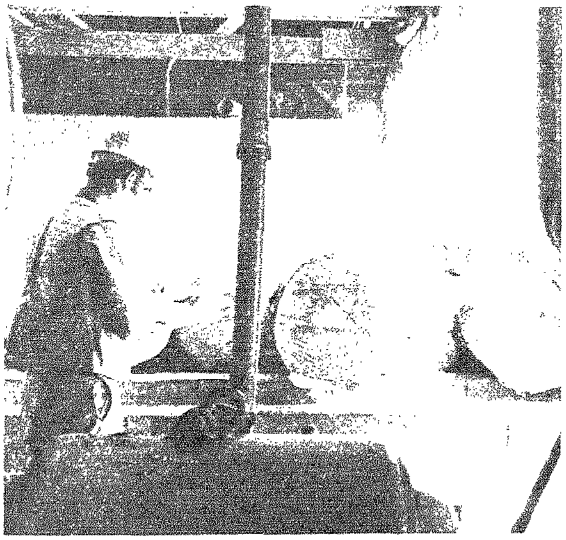
Figure 5.—Study logs being checked for tree-log number.

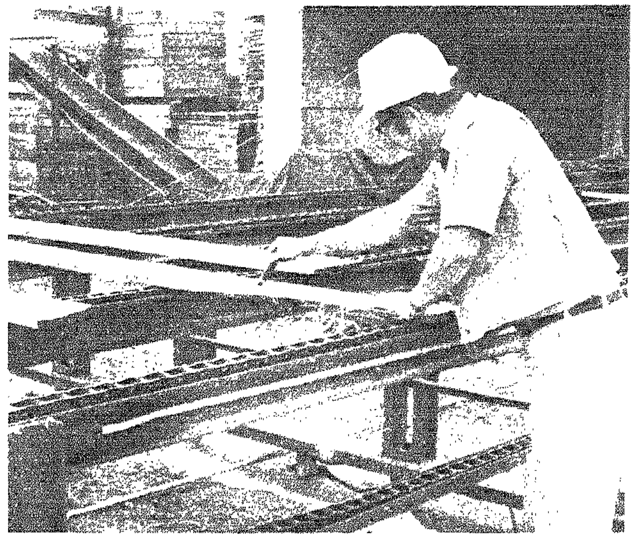
Figure 7.—Board numbering at trim saw.

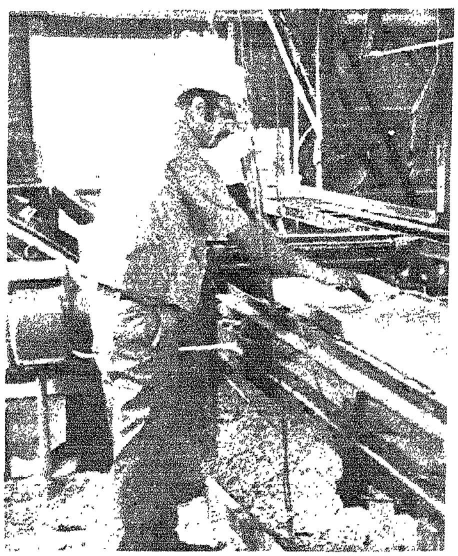
Figure 6.—Board numbering at edger saw.


Figure 8.—Study lumber being graded and tallied.

Species ____________ Date ____________

Green ______ Dry ______ Recorder ____________

GRADED LUMBER TALLY

SAWING ORDER NUMBER c.c. 1-3	LUMBER GRADE ACTUAL	LUMBER GRADE CODE c.c. 4	THICK-NESS c.c. 5-6	SURFACE MEASURE c.c. 7-8

LUMBER GRADE CODES

1 FAS
2 FAS1F
3 SELECT
4 SAPS
5 1C
6 2C
7 SW
8 3A
9 3B

Figure 9.—Suggested form for recording graded board information.

often high, and tallying does not usually proceed as fast as sawing. Somewhere in the drying yard or a nearby shed will be satisfactory (fig. 8).

If dry lumber grade yields are desired, study lumber should be properly stacked for air- or kiln-drying, and tight control should be maintained so that all boards are available for dry grading.

As the lumber is being measured and graded, the sawing-order number, previously placed on the board, must be read and tallied along with the board's thickness, surface measure, and lumber grade. A suggested tally sheet is shown in figure 9.

Analytical Procedure

For the initial step in this procedure, a card should be punched for each board. If the board information is recorded on the suggested tally sheets, cards may be punched from them after editing for readability and completeness. Each board card must contain the sawing-order number and the grade, thickness, and surface measure of the board.

A computer program should be written that will read a board card, determine the tree-log number, compute the volume of each board, and sum the volume by lumber grade for each tree. This lumber-grade volume information, along with each tree's number, grade, dbh, and merchantable height, can then be punched onto tree cards. It may also be desirable to include total lumber volume for the tree and a code for species.

With the complete tree information available, a prediction equation can be computed for each combination of tree grade and lumber grade. An equation with the following form has proved satisfactory in the past:

Lumber-grade yield $= a + b\ (\text{dbh})^2 + c$ (merchantable height) $+ d$ (dbh^2 x merchantable height)

Predicted lumber-grade yields are obtained by using the regression coefficients with various combinations of dbh and merchantable height. These yields, when brought together, result in a lumber-grade yield table for a species and tree grade (table 1).

Development of Total Lumber Volume and Value Predictions

A sawmill operator may be interested in predicting only total volume and value of lumber that can be produced from standing trees, and not lumber-grade yields. If so, the field procedure is comparable to that presented earlier, with one exception: *only 30 trees per grade are required.*

The mill and lumber-grading procedures and the analytical procedure through punching of board cards are the same as outlined above. After the board cards are punched, they are used with a program that computes total lumber volume and value for each tree and creates a card for each tree that contains this information, along with the tree's number, grade, dbh, and merchantable height in feet. To compute value, a schedule of lumber prices

Table 1.—Lumber-grade yield for yellow birch [In board feet]

Dbh (inches)	Tree grade 3, 2½-Logs						
	FAS	FASIF	Selects	No. 1C	No. 2C	No. 3A	No. 3B
12	0.4	2.1	1.6	17.9	41.2	36.3	28.8
13	.6	3.0	1.7	22.7	45.3	37.4	29.6
14	.9	4.0	1.7	27.9	49.6	38.5	30.6
15	1.2	5.1	1.8	33.4	54.3	39.8	31.5
16	1.5	6.2	1.9	39.4	59.4	41.1	32.6
17	1.8	7.4	2.0	45.7	64.7	42.6	33.7
18	2.2	8.7	2.0	52.4	70.4	44.1	34.9
19	2.6	10.0	2.1	59.5	76.4	45.7	36.1
20	3.0	11.5	2.2	67.0	82.7	47.4	37.5
21	3.4	12.9	2.3	74.9	89.3	49.2	38.8
22	3.8	14.5	2.4	83.2	96.3	51.0	40.3
23	4.3	16.2	2.5	91.8	103.6	53.0	41.8
24	4.7	17.9	2.6	100.8	111.2	55.0	43.4

by lumber grade and thickness must be developed. By applying the appropriate price to each board card, value of the boards is obtained; and when it is summed by tree, value of the lumber in each tree can be punched onto the tree cards.

Prediction equations using total lumber volume and total lumber value as dependent variables can be computed for each tree grade. The independent variables are the same ones used earlier: dbh^2, merchantable height, and $dbh^2 \times$ merchantable height.

Regression coefficients derived for the total-lumber-value equations are relevant as long as the price schedule remains unchanged. When lumber prices change, tree values should be updated and a new value equation should be computed for each tree grade.

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Appendix

How to Estimate Lumber-Grade Volumes for Non-Typical Trees

We stated earlier that non-typical trees should not be used for developing prediction equations. However, such trees do exist, and a procedure should be established for predicting their lumber volumes and values when they are encountered during an appraisal.

For trees that fork, it is common practice to assume that merchantable height extends from the ground to the top of the longest fork. This length will be less than the total bucked-log length; but when it is used in the prediction equations, the estimated lumber volumes will compare favorably with what is actually sawed.

When trees are encountered that have diameters larger than those found in the original sample, we suggest the following:

1. Refer to HARDWOOD TREE GRADES FOR FACTORY LUMBER (*Hanks 1975*), to see if yields for the species and size class in question are available. If so, use them.
2. If published tree yields are not available, estimate grade and volume on a log-by-log basis, using log-grade yields that include large logs (*Vaughan and others 1966*).
3. If neither of the above is possible, the operator can extend the yield equations for his mill to include the trees in question. Careful checking is required to assure that these yields are realistic.

For trees that have excessive defect above or below the grading section, we suggest that lumber-grade volumes and values be reduced by an amount equal to the percentage of defect in the merchantable portion of the tree. *Excessive* is difficult to define, but we suggest that, anytime a length of 8 feet or more within the merchantable length must be culled, the volume within this section should be expressed as a percentage of the total volume, and lumber-grade volumes should be reduced accordingly. Table 2 will prove useful for estimating the percentage of tree volume contained in various portions of hardwood trees.

Table 2.—Distribution of volume within sawlog portion of trees [In percent]

Length of piece (feet)	Tree segment, in feet															
	0-4	4-8	8-12	12-16	16-20	20-24	24-28	28-32	32-36	36-40	40-44	44-48	48-52	52-56	56-60	60-64
16	29	26	24	21	—	—	—	—	—	—	—	—	—	—	—	—
20	24	22	20	18	16	—	—	—	—	—	—	—	—	—	—	—
24	19	18	16	16	16	15	—	—	—	—	—	—	—	—	—	—
28	17	16	15	14	14	12	11	—	—	—	—	—	—	—	—	—
32	15	14	13	12	12	12	11	10	—	—	—	—	—	—	—	—
36	14	13	12	12	11	11	10	9	8	—	—	—	—	—	—	—
40	12	12	11	11	10	10	9	9	8	8	—	—	—	—	—	—
44	12	11	11	10	10	9	9	8	8	7	6	—	—	—	—	—
48	12	10	10	9	9	9	8	8	8	7	6	5	—	—	—	—
52	11	10	10	9	9	8	8	7	7	6	6	5	4	—	—	—
56	10	10	9	9	9	8	8	7	7	6	6	5	4	3	—	—
60	10	9	9	9	8	8	7	7	7	6	6	5	4	3	3	—
64	9	9	9	8	8	7	7	7	7	6	5	5	4	4	3	3

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