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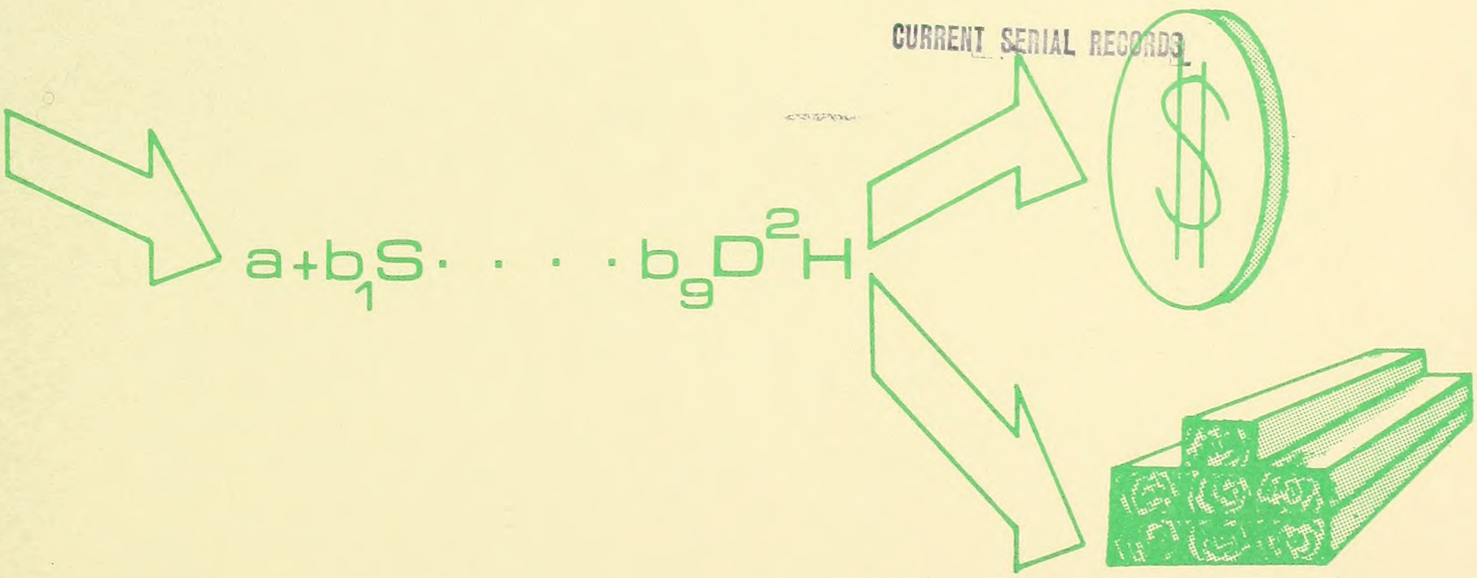
A NEW AND EASIER WAY TO ESTIMATE THE QUALITY OF INLAND DOUGLAS-FIR SAWTIMBER



by

Paul H. Lane, Marlin E. Plank,
and John W. Henley

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION · PORTLAND, OREGON
FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

FOREWORD

Inland Douglas-fir constitutes an important part of the Nation's sawtimber resource. Some 6 billion board feet of inland Douglas-fir sawtimber are cut annually, of which a sizable portion (about 40 percent) is cut from Federal and State lands.

The public agencies and the forest industry are much concerned with how this timber is appraised for sale. An important and difficult part of the appraisal job is estimating the quality of a tract of timber in terms of the amount of the various grades of lumber or other primary products that can be produced from it.

The Forest Service in cooperation with other public agencies and the forest industry is conducting research to develop better methods for estimating the potential lumber and veneer grade yield from standing timber. This report describes progress in meeting this objective: the development of a better timber grading system for inland Douglas-fir sawtimber.

The tree grading system described employs a new concept for evaluating the quality of timber and promises to make the timber appraiser's job easier and more accurate. If this report stimulates questions, suggestions, or other comments, we shall appreciate having them.

PHILIP A. BRIEGLEB
Director

A common method of appraising individual tracts of sawtimber for sale is to start with an estimate of the selling value[1] of the lumber that can be produced from the entire stand being sold. Stumpage value is then derived by subtracting such various estimated production costs as roadbuilding, logging, milling, and an allowance for profit and risk from the estimated lumber selling value.

The lumber selling value is usually determined by cruising all or a sample of the trees in the stand to obtain an estimate of the timber volume and quality. Volume is normally expressed in terms of board feet and derived by applying the cruise measurements of tree size to appropriate volume tables. Quality is estimated by applying a log grading system to the cruised trees. Dollar value is then determined by applying appropriate lumber prices to log grade lumber yield tables developed from mill recovery studies.

Most log grading systems for standing timber segregate sections of the stem or "logs" into discrete value classes. The timber cruiser determines the grade of each log in the tree--usually in 16-foot units. The standing tree log grades for inland Douglas-fir developed by the Pacific Northwest Forest and Range Experiment Station are an example of a discrete grading system.[2]

This paper, written primarily for timber appraisers, describes a new and improved method for estimating the lumber selling value of individual tracts of inland Douglas-fir sawtimber. The method was developed as a companion or alternative to log grading.

The system differs from the conventional log grading procedure in two principal ways: (1) it provides a selling value estimate for each cruise tree as a unit--therefore, it is more appropriately designated a *tree* grading system than a *log* grading rule, and (2) the system does not group trees into restricted or discrete quality classes--it is a nondiscrete or a continuous system where the estimated value of each tree is in itself a "grade."

The following describes the system, its development, and some examples of its performance.

The System and How It Was Developed

The end product value of a tree is largely dependent on its physical (quality) characteristics and the way it is processed. The basis for developing a good

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[1] Dollar value of lumber f. o. b. mill.

[2] Paul H. Lane. Grades for inland Douglas-fir saw logs in standing trees. Pacific Northwest Forest & Range Exp. Sta., USDA Forest Serv. Res. Note PNW-19, 5 pp., 1964.

timber grading system is determining which tree and log characteristics are important and the relationship of these quality features to end product yield and value.[3]

This tree grading system was developed by studying the quality characteristics and lumber yield from 1,099 inland Douglas-fir trees selected from typical commercial sawtimber stands. The trees were selected from 41 sample areas in Idaho, Montana, Oregon, and Washington (fig. 1). They were processed in a similar manner at four typical sawmills. Total lumber yield from the study trees was about 733,000 board feet.

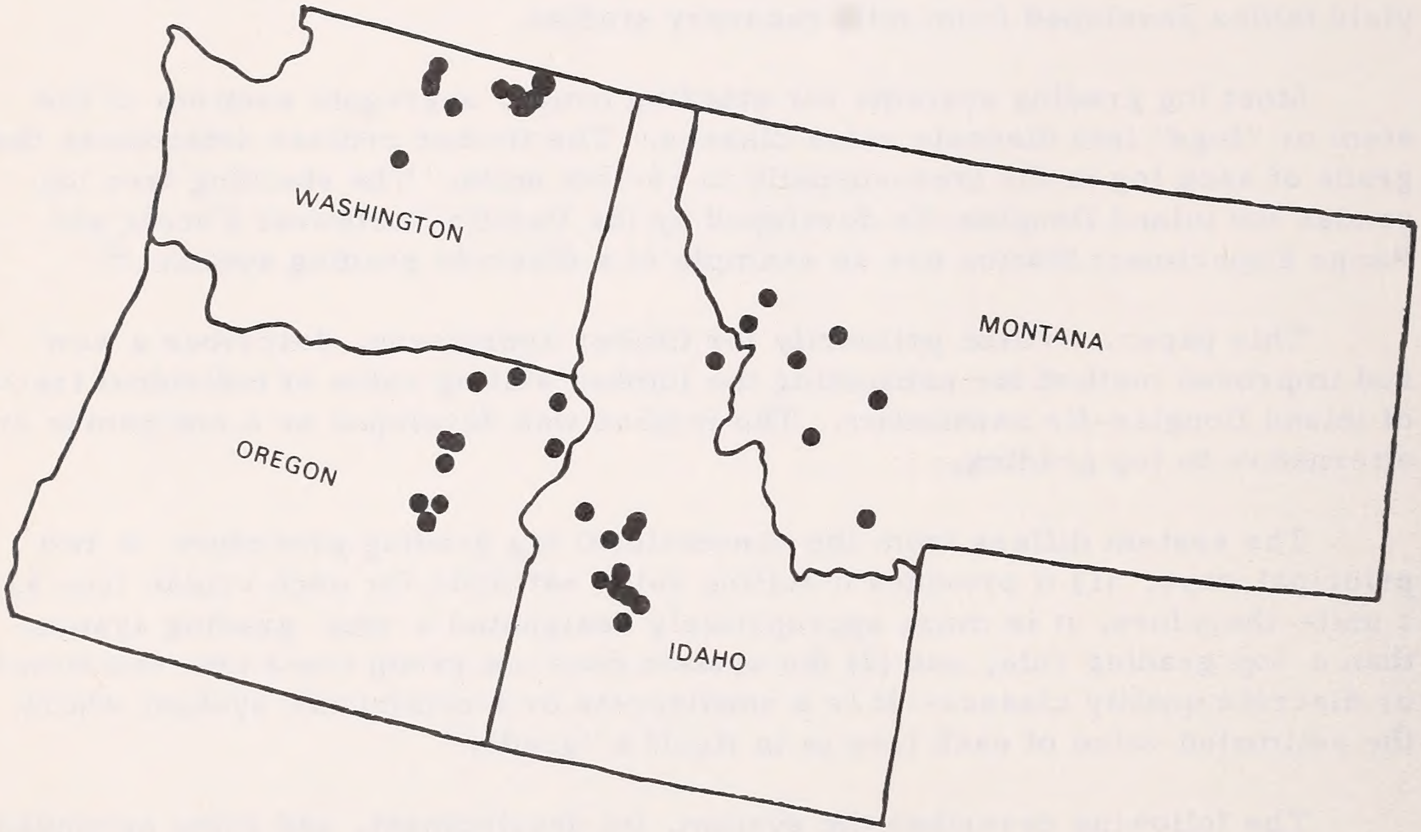

Figure 1.--General location of the 41 areas from which study trees were cut.

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[3] Paul H. Lane. Evaluating log and tree quality for wood products. Forest Prod. J. XIII(3): 89-93, illus. 1963.

R. M. Marden. New approach to tree grading for northern hardwoods. Forest Prod. J. XV(5): 179-184. 1965.

Carl A. Newport, C. R. Lockard, and C. L. Vaughan. Log and tree grading as a means of measuring quality. Forest Serv., USDA, Washington, D.C., mimeographed report for the National Log Grade Committee, May 1959.

In the development of the grading system, multiple regression analysis was used to determine the relationship of many tree characteristics to the lumber yield. The characteristics that had little or no effect on lumber value, or were difficult or impossible to quantify in cruising, were screened out.

More than 30 independent variables quantifying the tree characteristics were investigated in the regression analysis. The principal dependent variables were total lumber value (dollars), total lumber volume, and various groupings of lumber grade volume.

Five quality characteristics survived as the most important and practical criteria for grading trees:

1. Tree diameter
2. Tree height
3. Basal scar length
4. Diameter of the largest limb (or limb stub) in the butt 16-foot portion of the stem
5. Defect

These five variables and the lumber yield data were used to develop a number of trial regression equations for predicting the total lumber tally volume (board feet), value (dollars), and the yield (board feet) of Standard and Better lumber on a tree basis. One equation was finally selected as being the most practical with respect to application in timber appraisals and as statistically accounting for the most variation in lumber volume and value. The equation for predicting tree value is:

$$\$ = a + b_1S + b_2H + b_3D + b_4L + b_5P + b_6D^2 + b_7P^2 + b_8DH + b_9D^2H$$

where

\$ is the predicted total dollar value of lumber recovery for an individual tree.

S is length of basal scar in feet.
H is tree height in feet.
D is tree diameter in inches at 4-1/2 feet above ground.
L is diameter of largest limb in inches in butt 16-foot log.
P is estimated percent defect of gross cruise volume.
a is constant for the Y intercept.
b's are the regression coefficients.

The *basal scar* specification refers to a characteristic commonly found in inland Douglas-fir. This type of timber defect is often described as a fire scar, cat face, or frost crack (fig. 2). Such scars generally indicate that the underlying wood is decayed, excessively pitchy, or severely checked to the extent that lumber recovery is affected.

A

B

Figure 2.--Typical basal scars in Douglas-fir sawtimber.

A. Fire scar with decay.
B. Seam or "frost crack."
C. Scar commonly called a "cat face"--origin may have been from fire or mechanical damage.
D. Superficial (not degrading) scar caused by recent logging.

C

D

Fresh scars or injuries that, in the judgment of the timber cruiser, are superficial with respect to lumber recovery are disregarded.

The *limb* or limb stub specification is indicative of the size and character of knots that may be expected in the lumber produced. Knot size is directly related to lumber grade and value.

The *defect* estimate includes deductions made from the gross cruise volume for visible abnormalities such as crook, conks, cankers, burls, and bumps; and from the estimated volume loss from unknown sources such as logging breakage and hidden or internal defects such as shake, rot, and pitch rings.

The *a constant* identifies the appropriate Y intercept and indicates that a merchantable tree cannot have zero volume or value.

The *b*'s are the regression coefficients developed from a covariance analysis of the regression equations for each of the four base mill studies described previously. In application, they will vary according to the specific lumber prices used. Procedures for developing appropriate coefficients are included in the following section.

Two additional equations were developed to supplement this basic value prediction equation. They are (1) an equation to predict the total lumber tally volume of a tree, and (2) the volume of Standard and Better lumber grades. These two equations have the same form as the dollar value equation.

The equations developed from the four recovery studies account for 87 percent of the total variation in dollar value, 93 percent of the lumber volume variation, and 79 percent of the Standard and Better variation as measured by the regression R^2 values.

The system's simplicity affords considerable flexibility to fit any particular timber appraisal situation.

How To Use the System

Access to computer facilities for making regression analyses, covariance analyses, and solving equations is essential for efficient use of the system.

It will also be necessary to have, in a form suitable for computer use, the tree characteristic data (the five grading criteria) and lumber grade yield data for each of the 1,099 trees from the four mill studies used to develop this system. These data can be reproduced from a source deck of hollerith cards available for loan from the Timber Quality Research Work Unit, Pacific Northwest Forest and Range Experiment Station, P.O. Box 3141, Portland, Oregon 97208. The card format is illustrated in the appendix.

A step-by-step procedure for estimating the lumber volume and selling value of a group of trees or tract of timber is as follows:

1. Select an appropriate number of sample trees. Various timber cruising guidelines are available for choosing an adequate sample.[4/]

2. Measure and record for each sample tree the five characteristics: (1) scar length, (2) tree height, (3) tree diameter, (4) limb size, and (5) defect percent.

3. Assign desired lumber prices to each of the lumber grades (or combinations) recorded in the four base studies.

4. Using these assigned lumber prices, compute a total dollar value for each of the 1,099 trees from the four base studies.

5. Use an appropriate multiple regression program to develop the value equation coefficients for the 1,099 trees. Use assigned lumber prices (step 4) and the five tree characteristic variables and transformations as follows:

Independent

S
H
D
L
P
D^2
P^2
DH
$$\frac{1}{D^2H}$$

Dependent

Total dollars

All variables must be multiplied by $\frac{1}{D^2H}$ to equalize variance.

6. Make a covariance analysis of the four base study value equations to obtain appropriate coefficients for the common equation. Some computer programs will perform multiple regression and covariance analysis in one operation.[5/]

4/ David Bruce. Charts for determining sampling rate and number in sample. Pacific Northwest Forest & Range Exp. Sta., USDA Forest Serv. Res. Note PNW-97, 6 pp. 1969.

5/ Such as the Pacific Northwest Forest & Range Experiment Station's program RECO (CDC 6400 or IBM 7040).

7. Solve the value equation for the selected sample trees (step 1) using the covariance coefficients developed in step 6.

8. Predict the total lumber tally volume of each sample tree by using the equation with the following coefficients:

$$\text{Total lumber tally volume (bd. ft.)} = -33.763095 - .522607(S) - .319531(H) + 1.016213(D) - .083392(L) - .909085(P) - .124714(D^2) - .004588(P^2) + .060791(DH) + .010848(D^2H)$$

9. Estimate the volume of Standard and Better lumber for each sample tree by using the equation with the following coefficients:

$$\text{Volume of Standard and Better (bd. ft.)} = +88.638546 - 1.774408(S) - 4.104304(H) - 1.820890(D) - 2.823189(L) - 1.510553(P) - .563189(D^2) + .002798(P^2) + .434559(DH) + .002351(D^2H)$$

How the System Performs

The major objective of a timber appraisal grading system is to predict the value of a group of trees (usually 50 or more depending on the size and variability of the stand to be sampled). Obviously, the predicted and/or actual value for any one tree in such a sample may vary considerably from the group mean value. This variation is due primarily to the defects and other inherent characteristics of the timber and the way it is manufactured.

To illustrate how this tree grading system performs, it was applied to three commercial timber sales having about the number of trees that might be selected as a sample in making the quality estimate in a typical inland Douglas-fir sale. On each sale, the five quality criteria measurements were recorded for the trees by the cruiser. Predictions of the lumber selling value and volume were then calculated using the procedures described above. The actual lumber selling value and volume information were obtained by sawing the sample trees in a typical mill. Comparisons of estimated and actual values are shown in table 1.

It is noteworthy that the deviations of estimated from actual are not biased in one direction--two estimates are a little higher than the actual and one is a little lower. The predictions of lumber value are well within what might be the expected performance standard of any grading system.

Table 1.--*A comparison of actual vs. predicted lumber selling value for three inland Douglas-fir timber sales*[1/]

Timber sale	Number of trees	Lumber value		
		Estimated	Actual	Percent difference
		- - - - *Dollars* - - - -		
Northeastern Montana	168	4,323	4,088	+5.7
Northern Idaho	45	2,128	2,229	-4.6
Flathead Lake area, Mont.	158	4,510	4,392	+1.0

1/ Timber sales conducted in 1969 by the Northern Region, National Forest Systems, U.S. Forest Service, Missoula, Mont.

Conclusions

Field application tests of the system have demonstrated that it has a number of advantages over the conventional log grading method. It is faster to apply and therefore more economical; it requires less experience and judgment by the timber cruiser; and the training and checking of cruisers is easier.

Computation of the selling price also has some advantages over the conventional method of weighting the cruise volume by log grade and adjusting yield by log overrun estimates. Selling price is computed more directly; the quality characteristics of each sample tree are given more weight; and the computation procedures are relatively simple.

This system has been used successfully by the U.S. Forest Service and the timber industry for more than 2 years in computing the selling value of inland Douglas-fir on commercial timber sales in the northern Rocky Mountain area. Its performance and acceptance by both timber buyers and sellers indicate it is a relatively simple yet accurate method for estimating the quality of inland Douglas-fir sawtimber.

APPENDIX

The tree quality characteristic and lumber yield data for each of the 1,099 inland Douglas-fir trees from the four base studies are entered on punchcards according to the card format shown below.

Card columns	*Information*	
1	Study number	(X)
2-4	Tree number	(XXX)
5-6	Scar length	(XX)
7-9	Total height	(XXX)
10-12	D.b.h.	(XX.X)
13-14	Largest limb in butt 16-foot log	(X.X)
15-17	Percent defect	(XXX)
18-21	B Select	(XXXX)
22-25	C Select	(XXXX)
26-29	D Select	(XXXX)
30-33	1 Common	(XXXX)
34-37	2 Common	(XXXX)
38-41	3 Common	(XXXX)
42-45	4 Common	(XXXX)
46-49	5 Common	(XXXX)
50-53	Select Structural	(XXXX)
54-57	Construction	(XXXX)
58-61	Standard	(XXXX)
62-65	Utility	(XXXX)
66-69	Economy	(XXXX)
70-74	Total lumber volume	(XXXXX)

Trees from each of the four mill recovery studies are identified by a mill code number (card column number 1) and a separate color. The distribution of trees by mill studies is as follows:

Mill number	*Number of trees*
1	245
2	245
3	271
4	338
Total	1,099

Lane, Paul H., Plank, Marlin E., and Henley, John W.
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Estimating the amount and dollar value of lumber that can be produced from standing trees is a difficult part of the timber appraising job. A new and improved method, employing a new grading concept, was developed. A few basic timber characteristics that can be easily measured by the timber cruiser are applied in an equation to estimate the lumber volume and selling value of inland Douglas-fir trees. Information needed to apply the system is provided.

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