United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

Research Note
PNW-RN-457

January 1987

Pecky Rot in Incense-Cedar: Evaluation of Five Scaling Methods

James M. Cahill, W.Y. Pong, and
D.L. Weyermann

Abstract

A sample of 58 logs was used to evaluate five methods of making scale deductions for pecky rot in incense-cedar (*Libocedrus decurrens* Torr.) logs. Bias and accuracy were computed for three Scribner and two cubic scaling methods. The lumber yield of sound incense-cedar logs, as measured in a product recovery study, was used as the basis for comparison. Results showed that the most biased and least accurate scaling systems deducted the greatest percentage of log volume.

Keywords: Log scaling, defect deduction (-merchantable volume, pecky rot, lumber recovery, incense-cedar, *Libocedrus decurrens.*

Introduction

Incense-cedar (*Libocedrus decurrens* Torr.) is an important commercial softwood species in the Western United States. Currently, there are about 14 billion board feet of commercial size incense-cedar in the West; a majority of this volume is in northern California and southern Oregon (USDA Forest Service 1973b). Incense-cedar is manufactured into a variety of products including lumber, pencil stock, fenceposts, and shakes.

Although wood products manufactured from incense-cedar are recognized as extremely resistant to decay, standing sawtimber is highly defective. Pecky or dry rot (*Polyporus amarus* Hedgc.) causes extensive heart rot in trees throughout the range of this species (Boyce 1920, Wagener and others 1958). In the early stages of decay, pecky rot occurs in small scattered pockets confined to the heartwood (fig. 1a). As the decay intensifies, the number and size of the decay pockets increase and eventually coalesce (fig. 1b). The varying amount and scattered occurrence of pecky rot create problems for scalers trying to estimate the net volume of wood available for lumber production. Scalers often ask whether the scaling rules used to deduct for pecky rot are accurate: Do specific scaling rules deduct too much or too little for the presence of peck?

The purpose of this paper is to report the results of an analysis of five ways to make deductions for pecky rot. Three methods of Scribner deductions and two methods of cubic log scale deductions were analyzed for their ability to estimate the volume of wood available for lumber production. The scaling systems were compared by ranking the estimates of bias and accuracy.

JAMES M. CAHILL is a research forester, W.Y. PONG is a research forest products technologist, and D.L. WEYERMANN is a computer programmer, Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, Oregon 97208.

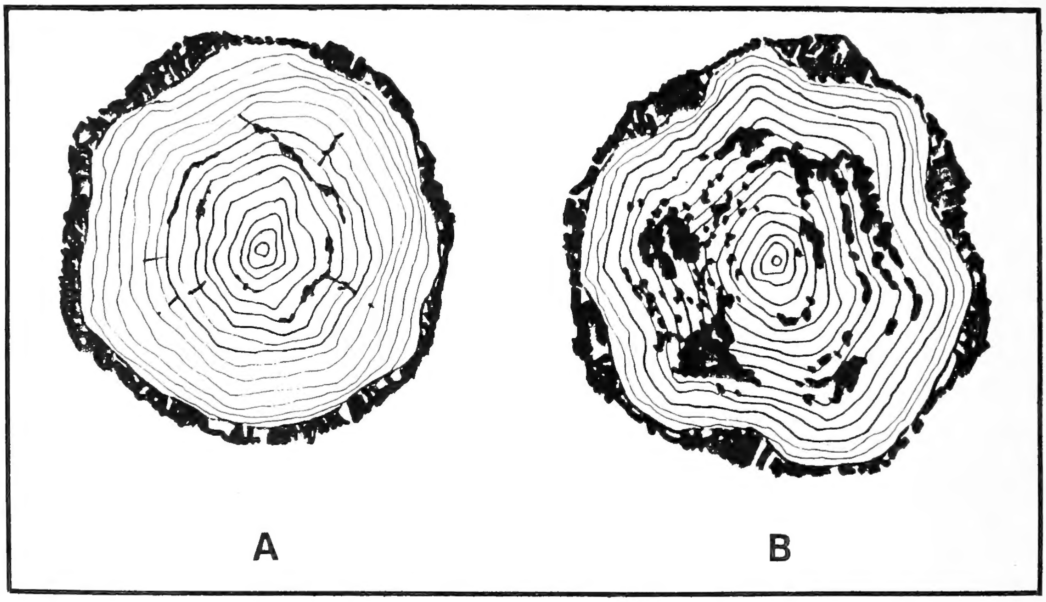

Figure 1—Incense-cedar log ends: **(A)** Scattered pockets typical of the early stages of decay. **(B)** Large, numerous decay pockets typical of advanced decay.

Methods

The general approach used to analyze the scaling options was to compare the lumber yield of logs containing pecky rot to the lumber yield of sound logs. Lumber yield and log scale data measured at a product recovery study were used. Fahey and others (1981) and Cahill (1983) used the same approach to analyze other scaling problems. Log scale deductions are considered accurate if the lumber yield based on the net volume of a log with peck in it is the same as the lumber yield of a sound log of equivalent volume.

Data Base

The data used to conduct this analysis were collected during a product recovery study in 1982. A total of 130 incense-cedar trees were selected from six areas in the Eldorado National Forest in California. Trees were selected to capture the range of quality and sizes that exists in incense-cedar. Diameter at breast height (d.b.h.) for the sample ranged from 16 to 54 inches. The pecky rot included in the sample represented the range of severity that would be seen in normal scaling operations.

Certified USDA Forest Service scalers recorded Scribner (USDA Forest Service 1973a) and cubic (USDA Forest Service 1978) scales on the woods-length logs prior to sawing. Deductions by scaling defect were recorded for each log and were based on all scaling methods. The logs were processed in a sawmill where moulding, shop, and board items were cut. Study lumber was tallied for individual logs after drying and surfacing. The percentage of lumber manufactured by grade group is shown:

Lumber grade	Percent
Moulding	10
Shop grades	36
3 & Better Common	29
4 Common	15
5 Common	10

Alternative Scaling Techniques

Deductions for pecky rot were made using the following Scribner and cubic scaling rules:

1. *Scribner standard scale.* Scale was taken using the standard National Forest log scaling handbook rules for Scribner scale (USDA Forest Service 1973a). All peck, regardless of the arrangement on the log ends, is deducted. Since this study was completed, Forest Service scaling practices have changed. Handbook rules now state that only pockets of peck less than 5 inches apart are considered as a scaling defect.

2. *Scribner 1¾-inch rule.* A deduction for pecky rot is made only when there is less than 1¾ inches of solid wood between pockets of rot as the pockets appear on the log end. For example, deductions would be made on a log where the pockets of peck were 1 inch apart. No deductions would be made if the peck holes were 2 inches apart.

3. *Scribner 4-inch rule.* A deduction for pecky rot is made only when there is less than 4 inches of solid wood between pockets of rot.

4. *Cubic, total deduction.* The cubic volume of rot is estimated using Smalian's formula. Diameters of the column containing the scattered peck are measured on both ends if possible. If peck shows on only one end, length of the rot column is estimated by the scaler.

Example: If a rot column of 10 inches shows only on the large end of a 33-foot log, the scaler would estimate that the rot extends 8 feet into the log and the peck deduction would be:

$$\text{Peck volume} = (10^2 + 10^2) \times 8 \times (0.0027274) = 4.4 \text{ cubic feet (CF)} ;$$

where:

10 and 10 = the diameters (in inches) of the rot column,
8 = the estimated length of the rot column (in feet), and
0.0027274 = a constant used to convert to cubic feet.

5. *Cubic, soft deduction.* Under this method the scaler estimates the volume of wood fiber that is decayed and not available for lumber production. If the scaler estimates that only 50 percent of the rot column of the log in the example above is in soft, unusable wood, then the cubic soft deduction would be 2.2 cubic feet (4.4 × 0.50).

Analysis Procedure

The first step in analyzing the scaling options was to sort the logs into two groups: Sound logs and logs with only peck as a scalable defect (pecky logs). Logs with defects other than pecky rot or logs with multiple defects were not included in the analysis. The following tabulation shows the number of logs, the average scaling diameter, and the range in diameters for the two groups of logs:

	Number of logs	Average diameter	Range in diameters
		(Inches)	(Inches)
Sound logs	185	12	6-31
Pecky logs	58	19	8-33

The second step in the analysis established the yield of lumber from sound incense-cedar logs. This provided a basis for comparing the different scaling options. Lumber yield of the sound logs is represented by the regression of rough green lumber tally in cubic feet over gross Scribner and gross cubic scales (figs. 2 and 3). The relation for gross cubic scale volume was simple linear function (fig. 3); a segmented regression was needed to adequately describe the relation between Scribner scale and cubic lumber tally (fig. 2). The segmented regression was necessary because Scribner scale underestimates the volume in small logs; hence, the rate of lumber recovery varies depending on log size. The regression was segmented at 240 board feet after we examined summary statistics (R^2 and standard error of the regression) for several models with different break points.

The final step in the procedure compared the actual lumber tally of a pecky log, after scale deductions, to the recovery of a sound log of the same net scale. The closer the lumber recovery of a defective log is to a sound log of equivalent volume, the better. Lumber yield for sound logs was estimated from the regression of lumber tally over scale volume (figs. 2 and 3).

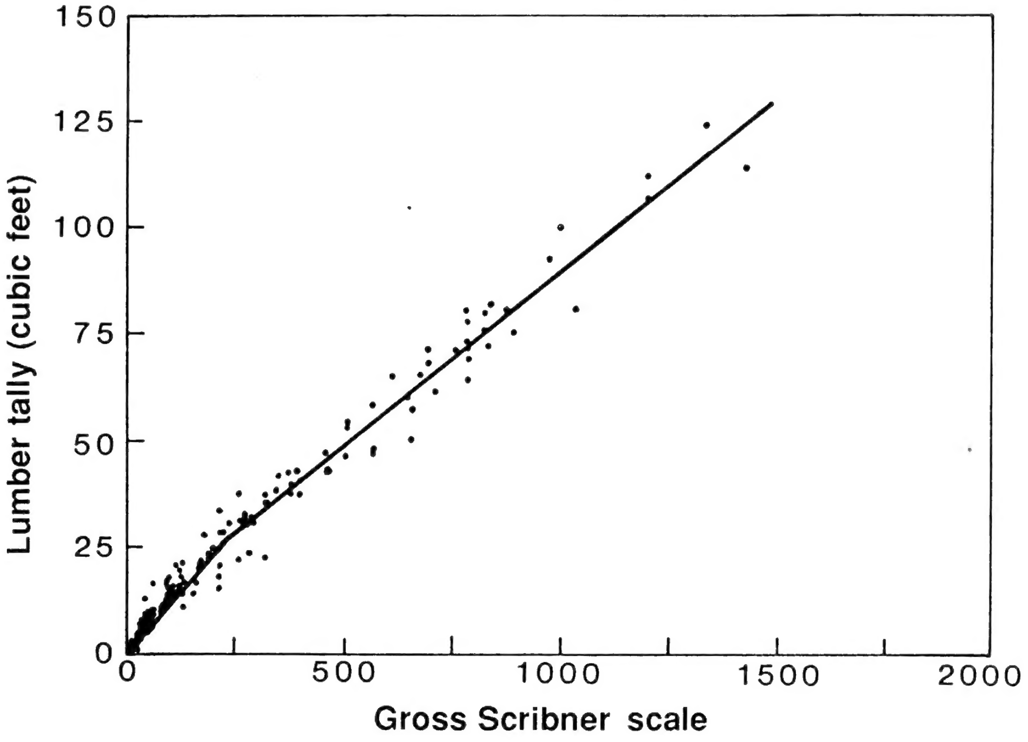

Figure 2—Regression line and data scatter of lumber tally (cubic feet) versus gross Scribner scale for sound incense-cedar logs. The regression equation is:

$$LT = 8.19 + 0.0807 * S - 0.0282 * I * (240 - S) ;$$

where:

LT = lumber tally,
S = Scribner log scale; and
I = an indicator variable ($I = 1$ when $S \leq 240$ and $I = 0$ when $s > 240$).

$R^2 = 0.98$; $N = 185$.

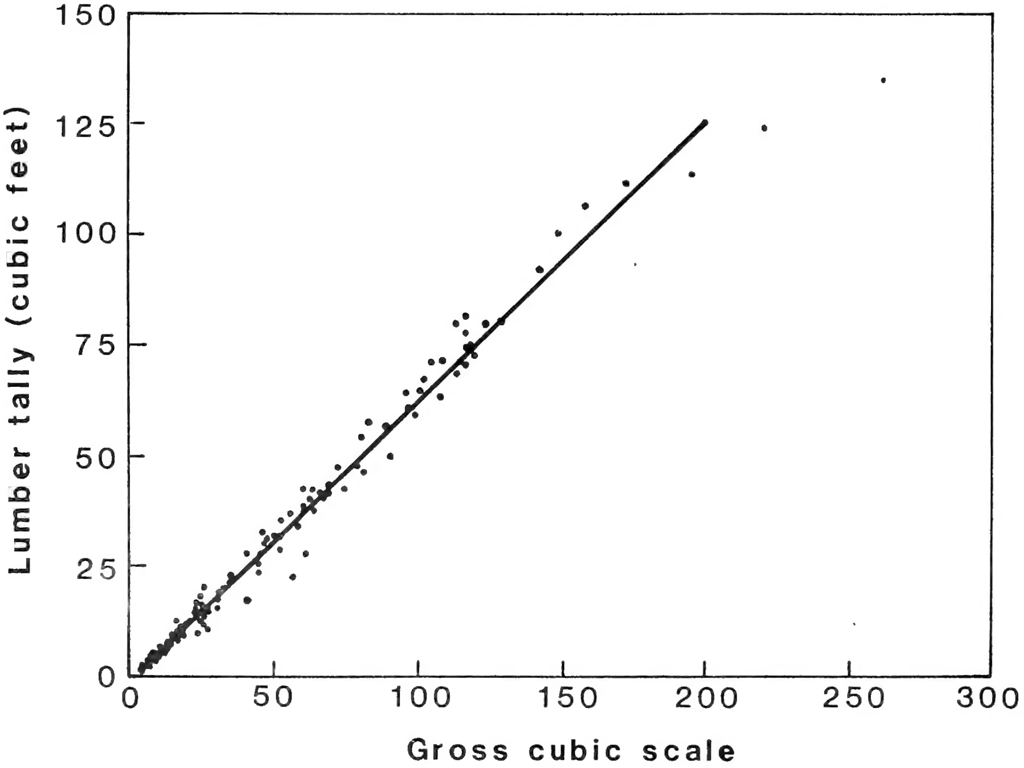

Figure 3—Regression line and data scatter of lumber tally (cubic feet) versus gross cubic log scale for sound incense-cedar logs. The regression equation is:

$$LT = -1.526 + 0.635 * CS ;$$

where:

LT = the lumber tally, and
CS = the cubic log scale.

$R^2 = 0.99$; $N = 185$.

An objective evaluation of the scaling options was made by comparing the average bias and accuracy for the 58 pecky logs and by using the lumber recovery of the sound logs as a base for comparison. Bias is defined as the average deviation of the actual lumber tally of a pecky log from the predicted tally of a sound log of the same net volume.[1] A system with little bias (bias close to zero) indicates that, on the average, the deduction is placing pecky logs on the same lumber yield basis as a sound log. Accuracy is defined as the square root of the average squared deviations[2] and is a measure of the variability of the yield of lumber from the pecky logs around the sound regression line. The larger the number associated with accuracy, the greater the variability. When the scaling options are evaluated, both bias and accuracy should be considered because a system that is both unbiased (a number close to zero) and accurate (a small number) is desirable.

Table 1 shows an example of the calculation of bias for a hypothetical incense-cedar log. It was assumed that pecky rot is the only defect in the log. Only the three Scribner scaling options are used in this example. The net log scales are different because each scaling option used different rules to estimate the amount of defect. The yield of lumber from a sound log for each net scale estimate was taken from the regression line in figure 2. Actual lumber tally would be the cubic feet of lumber measured at a product recovery study. Bias is the actual yield of lumber subtracted from the estimated yield of a sound log. In this example, the Scribner 4-inch rule worked best because that bias was closest to zero (+2.6). Accuracy was not computed in this example. The average bias and accuracy are used for large samples of defective logs to make comparisons among scaling systems.

---

[1] Estimate of bias is the average deviation where the deviation is actual recovery from a defective log *(y_i)* minus the predicted recovery of a sound log of the same volume *($\hat{y}_i$)*; that is, $\Sigma(y_i - \hat{y}_i)/n$.

[2] Estimate of accuracy is the square root of the average squared deviation; that is, $(\Sigma(y_i - \hat{y}_i)^2/n)^{1/2}$.

Table 1—Example of bias calculation for a hypothetical incense-cedar log

Scaling option	Net scale	Lumber yield[1] from a sound log	Actual lumber tally[2]	Bias[3]
	Board feet		*Cubic feet*	
Net 1¾-inch rule	350	36.4	33.0	33.0-36.4 = −3.4
Net 4-inch rule	275	30.4	33.0	33.0-30.4 = +2.6
Standard Forest Service scale	200	23.2	33.0	33.0-23.2 = +9.8

[1] Lumber yield for a sound log was estimated from the regression equations in figures 2 and 3.

[2] Actual lumber tally is the cubic feet of lumber measured at a product recovery study.

[3] Bias is the actual lumber tally, in cubic feet, minus the predicted lumber tally from a sound log.

Results

Table 2 shows the average bias and accuracy and the percentage of log volume deducted for the Scribner and cubic scaling options.

The 1¾-inch rule deducted the smallest amount of volume (28 percent) for the Scribner options and had the least bias and greatest accuracy. The positive sign associated with the bias (+4.95) indicated that, on the average, the deductions were still excessive. The standard Forest Service scale deducted the greatest volume (46 percent) and was the most biased and least accurate. A better estimate of net scale can be made by making no deductions for peck than by using the current, standard Forest Service scale.

Bias and accuracy for the cubic scales were best for the deduction that adjusted the volume of rot by the amount of wood actually decayed (cubic soft). This option also deducted the least amount of log volume. Making no deductions would have provided a better estimate of usable wood than the cubic total deduction.

The 58 pecky logs were then divided into two groups: (1) Logs with rot showing on one end (ROT1 logs, N = 25) and (2) logs with rot showing on both ends (ROT2 logs, N = 33). Rot occurred along the entire length of the woods-length, ROT2 log; the decay in the ROT1 logs ended at some intermediate point. The average bias, accuracy, and percentage of log scale deduction are shown for both groups in table 3.

We expected the logs in the ROT2 group to have a greater lumber loss than the ROT1 logs because they had decay scattered throughout the entire log length. This was confirmed by the data in table 3 that compares the average bias for gross Scribner and gross cubic scales. ROT2 logs, on the average, were more negatively biased than were ROT1 logs.

Table 3 also shows that all the scaling systems were more biased and less accurate for ROT2 logs than for ROT1 logs. The Scribner systems, for instance, tended to overdeduct when pecky rot occurred on both log ends, as compared with logs with rot showing on one end.

Greater bias and less accuracy were also present in the ROT2 logs when the cubic systems were used. The cubic soft method had a small bias on the ROT1 logs (bias = +0.79) but underdeducted (bias = -3.60) on the ROT2 logs.

Table 2—Average bias, accuracy, and percentage of scaling defect for incense-cedar logs with pecky rot as the only scaling defect [1]

Scaling option	Bias	Accuracy	Average amount of defect
	– – – Cubic feet	*– – –*	*Percent*
Scribner:			
Scribner gross	– 5.73	13.81	—
1¾-inch rule	+ 4.95	11.42	28
4-inch rule	+ 8.88	14.20	36
Standard Forest Service scale	+13.99	18.25	46
Cubic:			
Cubic gross	– 4.37	13.63	—
Cubic soft	– 1.71	11.37	5
Cubic all	+ 9.02	13.87	28

[1] Number of logs equals 58.

Table 3—Average bias, accuracy, and percentage of defect for logs with pecky rot showing on one end (ROT1) and logs with pecky rot showing on both ends (ROT2)

	ROT1			ROT2		
Scaling option	Bias	Accuracy	Average amount of defect	Bias	Accuracy	Average amount of defect
	-- Cubic feet --		*Percent*	*-- Cubic feet --*		*Percent*
Scribner:						
Gross Scribner	–2.79	6.54	—	– 7.96	17.40	—
1¾-inch rule	+2.67	7.79	19	+ 6.68	13.53	34
4-inch rule	+5.34	8.92	28	+11.56	17.14	43
Standard Forest Service scale	+9.14	12.91	36	17.66	21.43	54
Cubic:						
Gross cubic	–1.10	5.06	—	– 6.85	17.53	—
Cubic soft	+ .79	4.75	4	– 3.60	14.50	6
Cubic all	+5.86	11.96	18	+11.41	15.17	36

Conclusions

All Scribner scaling options overdeducted for the presence of pecky rot. The magnitude of bias was greater for logs with pecky rot showing on both log ends versus logs with rot showing on one end. The 1¾-inch rule performed best of the Scribner systems tested; it had the least amount of bias and the greatest degree of accuracy. Future efforts to revise the Scribner scaling rules for pecky rot should note that the scaling options that performed the worst were those that deducted the greatest percentage of log volume.

Of the cubic systems, the cubic soft method was superior to the cubic total method. The cubic soft method slightly overdeducted for logs with rot showing on one end and underdeducted for logs with rot showing on both ends.

Acknowledgment

We thank Larry Knecht, regional check scaler, USDA Forest Service, Pacific Southwest Region, for his assistance in defining the scaling systems and for his leadership during the scaling of the study logs.

Metric Equivalents

1 inch = 2.540 centimeters
1 foot = 0.305 meter
1 cubic foot = 0.028 cubic meter

Literature Cited

Boyce, J.S. The dry-rot of incense cedar. Bull. 871. Washington, DC: U.S. Department of Agriculture; **1920.** 58 p.

Cahill, J.M. Cubic log scale deductions in dead timber: an empirical approach. Forest Products Journal. 33(4): 21-24; **1983.**

Fahey, T.D.; Snellgrove, T.A.; Cahill, J.M.; Max, T.A. Evaluating scaling systems. Journal of Forestry. 79(11): 745-748; **1981.**

U.S. Department of Agriculture, Forest Service. National Forest log scaling handbook. FSH 2409.11. Amend 4. Washington, DC: **1973a.** 247 p.

U.S. Department of Agriculture, Forest Service. The outlook for timber in the United States, FRR-20. Washington, DC: **1973b.** 367 p.

U.S. Department of Agriculture, Forest Service. Cubic scaling handbook (a review draft). Washington, DC: **1978.** 200 p.

Wagener, Willis W.; Bega, Robert V. Heart rots of incense-cedar. For. Pest Leafl. 30. [Washington, DC]: U.S. Department of Agriculture, Forest Service; **1958.** 7 p.

*GPO 791 - 012 (1987)

Pacific Northwest Research Station
319 S.W. Pine St.
P.O. Box 3890
Portland, Oregon 97208

U.S. Department of Agriculture
Pacific Northwest Research Station
319 S.W. Pine Street
P.O. Box 3890
Portland, Oregon 97208