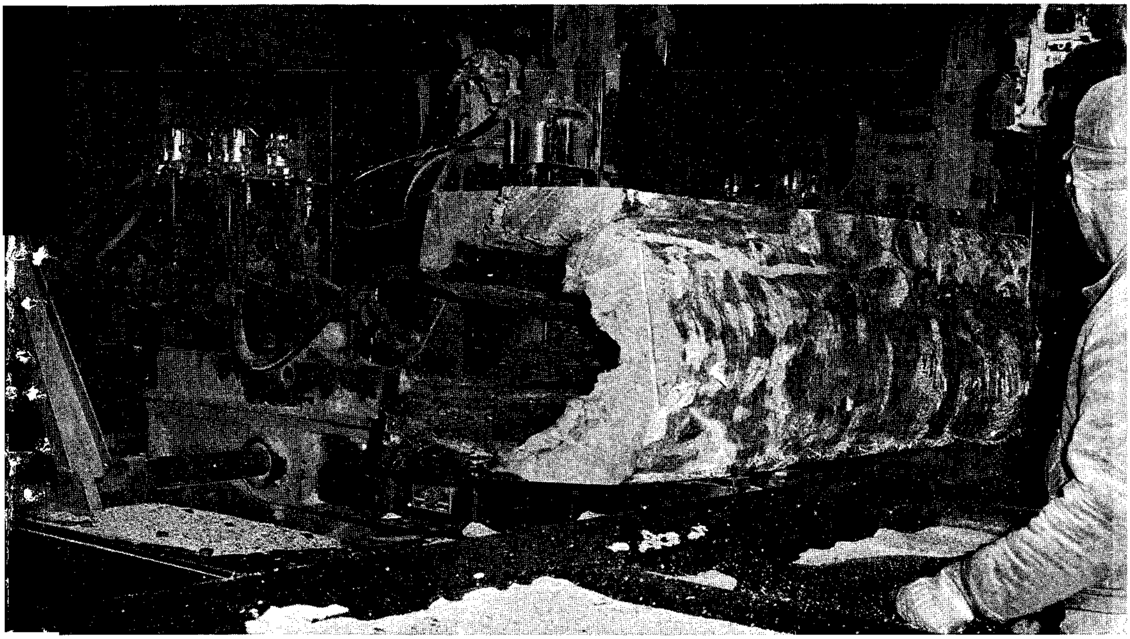
Technical Considerations in Harvesting and Sawing DEFECTIVE HARDWOOD BUTTS



by Thomas W. Church, Jr.

U.S.D.A. FOREST SERVICE RESEARCH PAPER NE-189
1971

NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
RICHARD D. LANE, DIRECTOR

THE AUTHOR

THOMAS W. CHURCH, JR., joined the USDA Forest Service's Northeastern Forest Experiment Station in 1946, after graduation from the Pennsylvania State University School of Forestry. He left the Station in 1955 to take a position with Whitney Industries, Inc., Sabattis, New York, in their forestry department. After 3 years in private industry he returned to the Forest Service and a position with the Lake States Forest Experiment Station. In 1964 he transferred back to the Northeastern Forest Experiment Station and to his present assignment at the Forest Products Marketing Laboratory in Princeton, West Virginia. Mr. Church has a master's degree in forest utilization from Duke University.

MANUSCRIPT RECEIVED FOR PUBLICATION 27 AUG. 1970.

THE IMPORTANCE OF BUTT DEFECTS

HOW IMPORTANT are butt defects in hardwoods? We have no reliable estimate of the volume or value of timber lost through basal injuries. However, butt defects will be almost as important in future timber harvests as they are at present. Why? Because most butt defects are due to two causes: fire and logging. Damage from both these agents may be reduced, but it certainly will not be eliminated.

Fire injury exposes large areas of the tree bole to the harmful effects of diseases that rot heartwood. A recent study in stands of oak saplings, poles, and sawtimber revealed that fire was the major cause of butt injury (*1*). Wildfire may cause even greater injury to other hardwood species. After a wildfire in cove hardwood saplings, investigators found that 41 percent of the desirable dominant stems that were not killed had basal scars or incipient rot (*2*).

Some residual stems are usually wounded during logging. The frequency and severity of this injury depends upon the cutting practices employed, the residual stand density, and the type of equipment used (*4, 8*). Position and size of the wound often govern the extent of the basal injury that develops as the trees grow. Although techniques have been developed for predicting the amount of internal damage from logging wounds on certain species, a reliable estimate of decay and discoloration from logging wounds on northern hardwoods cannot be made on the basis of external features alone (*8*).

Since the major causes of butt defect may continue to prevail in future decades, the utilization of this unsound timber will continue to challenge hardwood lumbermen. What policy should sawmill operators follow regarding the use of defective butts? Previous research has shown that internally defective butt logs from high-value species like maple and birch can be profitably harvested and sawed (*3, 5*). So loggers should remove unsound butt portions only (1) when the collar of sound wood surrounding rot or voids is less than 6 inches thick, or (2) when the combination of internal defect and butt flare are extreme. For butts with internal defects plus catfaces, the shell of sound wood must average 6 inches, including the open wound on the scarred face. Otherwise such a combination of butt defects should be bucked off.

If sawmills adopt these recommendations, supervisors should be aware of some of the technical problems they will face. The most important questions are: (1) How will the acceptance of defective logs influence truckload volume and hauling costs? (2) Can scalers accurately estimate the deductions for cull? (3) Are log sawing times substantially increased? (4) How does the value of lumber sawed from defective logs compare with the value of lumber sawed from sound logs?

The following discussions of these questions are based on the analysis of data collected from 219 sugar maple butt logs, 57 percent of which had internal defects. Our objective in presenting this information is not to establish relationships between the amount of internal defect and net sawlog value, but rather to show sawmill operators how their logging and milling practices might be affected if they utilize defective butts.

TRUCKLOAD VOLUME

Suppose sawmill operators decide to saw all but the most defective butts. How will this change in policy affect the business relationships between them and their contract loggers?

Certainly the contractors will realize that they have to deliver more gross volume for the same pay, because payment is based on net scale. Does transporting defective butts actually reduce net truckload volume? If so, contractors and truckers might rightfully expect to get a higher price per thousand board feet net scale to cover the extra loading and hauling costs.

Anticipating this problem in business relationships, we measured the gross and net volumes on trucks loaded with the type of logs meeting current merchantability standards. Then we compared these values with truckload volumes where at least one log on each load was one of our sample defective butts. A defective butt is defined as a log having an internal defect over 6 inches in diameter that warrants a cull deduction of at least 20 board feet.

These comparisons were based on 53 loads of merchantable logs and 79 loads of both merchantable and defective logs. Twenty-eight percent of the 79 loads of mixed logs had two or more defective butts per load.

Average net volume per load was nearly identical regardless of the condition of the logs hauled. Trucks hauling a mixture of merchantable and defective logs carried about 75 board feet more gross volume per load than trucks hauling merchantable logs only. And cull volume was about 80 board feet higher on loads with defective logs. The differences in average truckload volume—in board feet, Doyle scale—were:

Log volume class	*Merchantable logs*	*Merchantable and defective logs*
Gross	2,280	2,353
Net	2,223	2,214
Cull	57	139

These findings show that mill operators will not need to pay contractors more money for hauling defective logs because there was less than 10 board feet difference in the average net volume hauled. The greater gross volumes associated with loads containing defective logs may be attributed to the larger diameters of the unsound butts. The one or two big defective logs on each load apparently occupied the restricted cargo space more efficiently than the smaller logs normally carried.

Since extra trips would not be needed to haul a given net volume that included defective logs, logging costs should remain unchanged. In fact, logging costs might actually decline slightly. Under current utilization standards, contractors remove butt defects at their own expense rather than incur a scaling penalty.

SCALING ACCURACY

Operators who plan to saw internally defective butts should know whether they can measure net volume accurately. If company scalers cannot correctly deduct for internal cull, the net dollar income from defective logs could vary substantially.

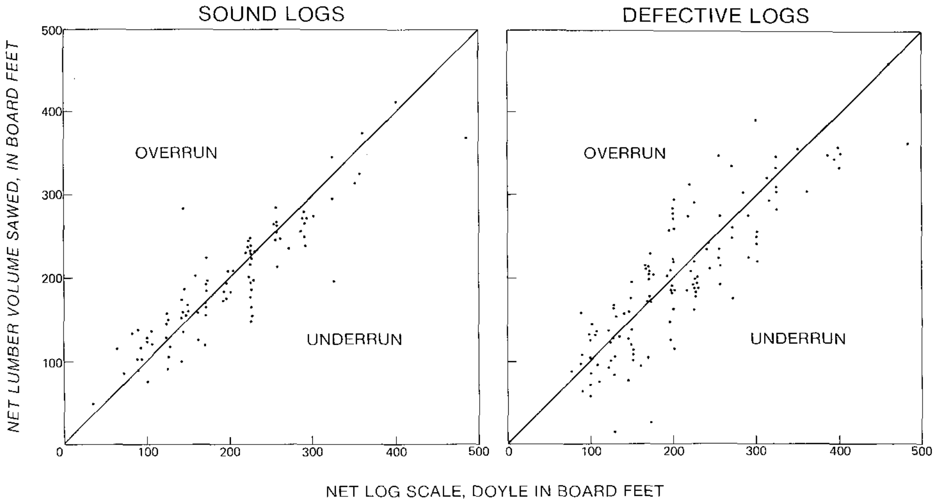
In the Appalachian area, most of the timber sales and contractor payments are based on the Doyle rule. When properly applied, this log rule usually gives a big overrun, especially for logs in the smaller diameter classes. But these underestimates of actual lumber volume are usually worked out in price negotiations. However, scalers using the Doyle rule have no reliable method for making cull deductions. They adjust for cull defects by reducing log diameter or length according to their best judgment of the cull volume. Such unscientific practices could seriously hamper efforts to utilize more of the partially defective timber now wasted.

In this evaluation, we had an excellent opportunity to compare the actual lumber yield with the scaled volume for each of the 219 sample logs used. Although the company scaler had been working with the same mill crew for several years, his estimates of net volume were considerably above and below the lumber yields from individual logs. Differences in overrun and underrun frequently exceeded 25 board feet per log. Occasionally the spread between lumber yield and log scale exceeded 100 board feet per log.

In plotting the overrun and underrun for individual logs, the dispersion for sound logs appeared to be more compact than the scatter for defective logs (fig. 1). This impression proved to be correct, for in evaluating the actual values, we found that the scaler made a poorer volume estimate of the defective logs. In fact, his percentage underrun for defective logs was more than twice that for the sound logs:

	Sound logs (board feet)	*Defective logs (board feet)*
Net scale	18,785	26,442
Overrun	1,040	2,065
Underrun	1,365	3,061
Net underrun	325	996
Percent of underrun	1.7	3.8

Figure 1.—Differences between log scale and lumber yield for sound and defective sugar maple butt logs.



We were surprised to find an underrun. Lumber yields from sound logs of this size should exceed scaled volumes when the Doyle rule is used. Obviously the company scaler made liberal estimates of net volume in both sound and defective logs. Since this timber came from company lands, the only beneficiary of this overestimate was the logging contractor, who was paid on the basis of net scale.

How much was the contractor overpaid? That depends upon what overrun factor the company used in setting the contract price. If they expected neither an overrun nor an underrun, then at $40 per MBF (thousand board feet) log scale, they paid the contractor about $0.70 per MBF too much for sound logs and about $1.50 per MBF too much for defective logs. But if the company expected a 10-percent overrun at the $40 per MBF delivered price, then they overpaid the contractor about $4.25 per MBF for sound logs and about $5.00 per MBF for defective logs. These figures illustrate why the level of scaling accuracy must be known in advance of price negotiations, especially when defective logs will be purchased.

SAWING TIME

Sawmill operators who plan to saw defective butts must face the fact that these logs take longer to saw. The average sawing time for unsound butts below 20 inches in diameter ranged from ½ to 1 minute longer than the average sawing time for sound logs of similar size. In the larger diameters, defective logs took 1 to 1½ minutes longer to saw than sound logs of equivalent size (fig. 2).

The sawyer handled defective logs with greater caution. The feed rate was slower—perhaps to minimize the danger of sudden collapse (fig. 3). Even though the sawyer exercised greater care, delays occurred when the off-bearer had to handle small wedged boards, or when the refuse system clogged from the large volume of waste suddenly dumped into it.

The relationship between log soundness and sawing time can be expressed in another way: the time required to saw a given lumber

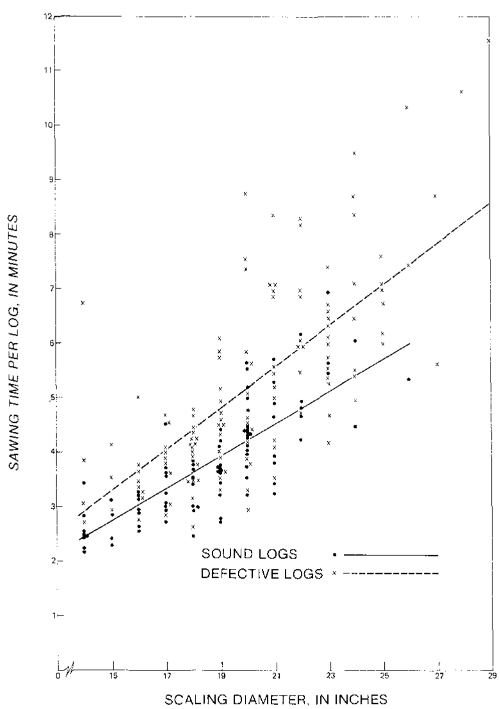


Figure 2. — Relationships between scaling diameter and sawing time for sound and defective maple logs.

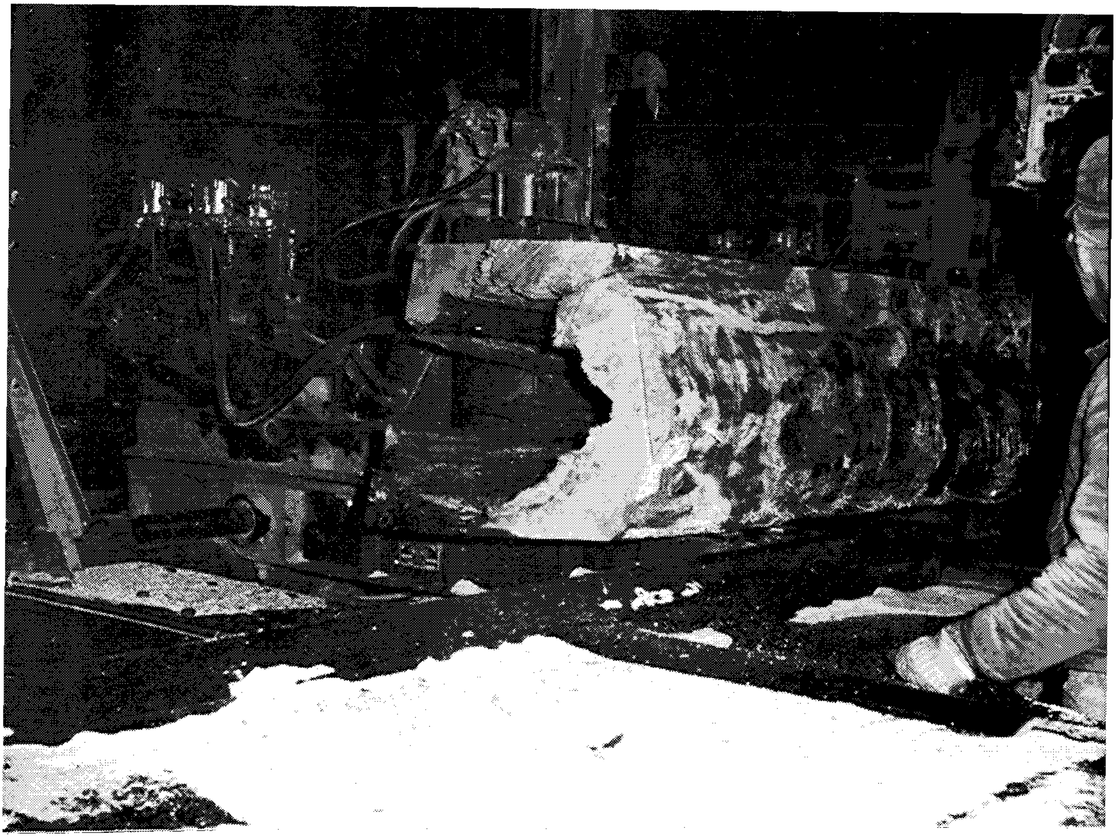


Figure 3.—Large internal defects reduce lumber output per hour because of greater caution exercised and occasional delays.

volume. Such a comparison may have greater meaning for millowners because it considers the net lumber yield per log rather than the log size.

In using lumber volume yield as a basis for comparing sawing time differences between sound and defective logs, we found an even wider spread than we observed in the plot of sawing time by log diameter (fig. 4). The sawmill crew took about 1 minute longer to saw 100 board feet of lumber from internally defective logs than from sound logs. When net lumber yield per log was 300 board feet or more, the additional sawing time needed to produce equivalent yields from defective logs was about 1½ minutes.

Analysts appraising these findings may wonder if there was a difference in log grade between the sound and defective specimens.

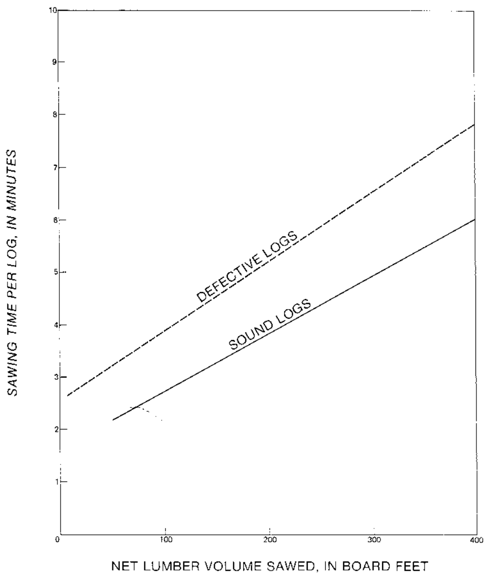


Figure 4. — Relationships between lumber volume yield and sawing time per log for sound and defective maple butts.

Log-quality appraisals were based on the USDA Forest Service grading system as described by Ostrander (7). Grade rules were applied precisely. Thus some logs were downgraded because of excessive internal defect.

Although all three grades of factory logs were well represented in both sound and defective categories, neither the diameters nor the number of logs were similar. For this reason, we decided to evaluate the importance of log grade on sawing time by performing a separate regression analysis for each grade. Results showed that the better grades of logs took slightly less time to saw than the poorer grades of logs of the same size. However, differences in sawing time due to log grade were insignificant.

Since we found that such a large spread in sawing times was due to log condition, lumbermen will want to know if hollow butts can be sawed profitably. Most of them can be—if standards on the minimum amount of sound wood are followed. Of course, log profitability depends on purchase price and scaling accuracy as well as on lumber-production costs, as represented by sawing time.

COMPARATIVE LOG VALUE

The final decision to use or not to use defective logs rests upon only one factor: profit. If millowners believe they can make money from unsound butts, they will buy and saw them. But if operators are convinced they cannot make a profit from hollow or rotten logs, then foresters might just as well forget about improving the degree of utilization from such defective timber.

To give you a picture of the profit or loss from sound versus defective logs, we have used the gross and net dollar yields from each of the 219 sugar maple logs. In the graphs used to illustrate these value comparisons the sample is divided into the three factory-log grades developed by the USDA Forest Service. Because of the close link between log grade and lumber value per log, the log-grade breakdowns enable you to see the value trends more clearly than if the entire sample were lumped.

Please understand that the actual dollar values used in this comparison are not up to date. The lumber selling prices, the assigned costs for delivered logs, and the sawmill operating costs, are all based upon 1967 figures. Lumber selling prices used in this evaluation were based on listings in the Hardwood Market Report (Memphis, Tenn.) 48(45): 24 pp., Dec. 1967. They were: FAS—$270, IF—$260, 1 COM—$185, 2 COM—$85, 3A COM—$75, and 3B COM—$45. Stumpage and logging costs were set at $55, $70, and $85 per MBF for log grades 3, 2, and 1, respectively.

Current lumber prices are higher. So are the costs of delivered logs and the costs of operating a sawmill. Regardless of what cost and price figures are used, they are likely to be unreliable in the future.

Actual dollar values based on current prices and costs are not nearly as important as comparative values. We believe you need to picture the relationship between sound and defective logs more than you need to know the exact profit or loss from a particular log or group of logs. Therefore, we have developed regression lines that best fit the plotted data for individual logs. By comparing the differences between the lines, you will get a good picture of the comparative value of sound versus defective butts.

Sawmill operators will probably be interested only in the sawlog dollar values obtained under actual operating conditions. There may be some researchers and analysts, however, who would like to consider potential log values if operating conditions had been different. For this reason, we are illustrating the comparative dollar value of sound versus defective logs for the following situations: (1) actual observed conditions, (2) elimination of log-scale inaccuracies, and (3) comparison of potential sawlog dollar values when both raw-material costs and lumber-production costs have been excluded.

Observed Conditions

Figure 5 shows the wide variation in net value per log for samples with similar characteristics. For sound logs of the same net scale and grade, it was common to find a range in net lumber value of $5 to $10 per log. For defective logs, this range in net

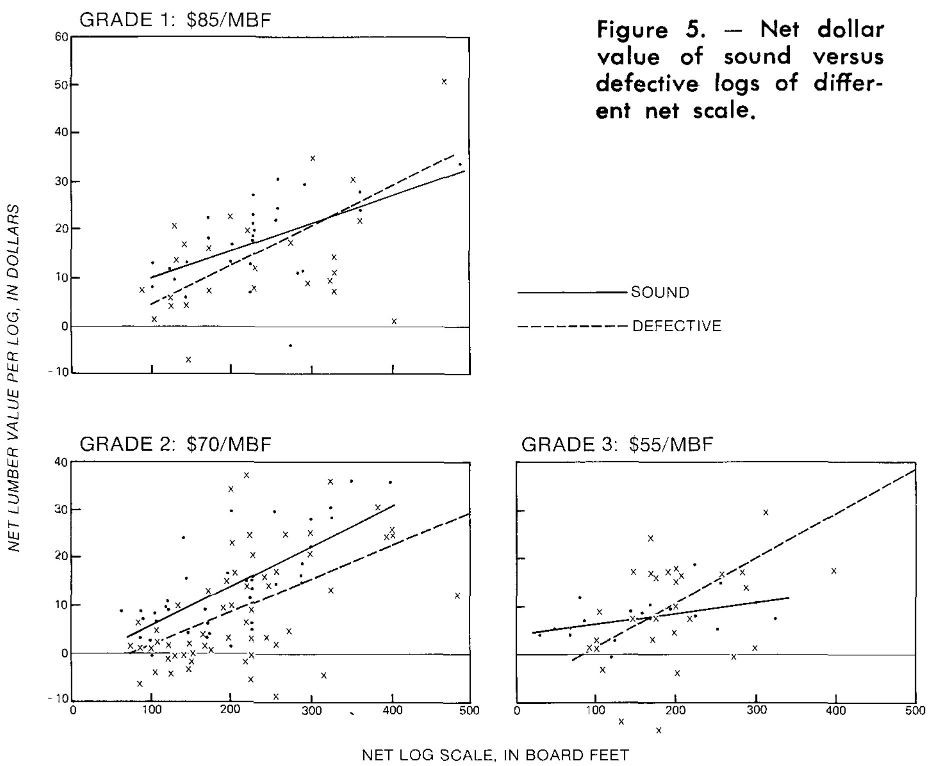


Figure 5. — Net dollar value of sound versus defective logs of different net scale.

lumber value was often greater: in a few instances it exceeded $30 per log.

Such broad ranges in net log value prevent us from making any uncompromising statement about the net worth of sound logs versus defective logs. However, our analysis of log values indicated that, in log grade 1, the average sound log was worth about $1.50 more than the average defective log. In log grade 2, the average sound log had about a $5 greater net value than the average unsound log. In log grade 3, however, the situation was reversed: the average defective log was worth about $3 more than the average sound log.

We expected the sound logs to be more valuable because: (1) the scaler made a larger overestimate of net volume in defective logs, and (2) the sawyer took longer to cut the same volume of lumber from defective logs. In fact, we were surprised to find that the differences in net value between sound logs and defective logs were not greater. However, the low-grade lumber in the heart center rarely sells for its cost of manufacture plus stumpage, so that is why there was not much difference in value between sound logs and defective logs where some or all of this low-grade material was missing.

The defective logs tended to have larger diameters than the sound logs. Thus the unsound logs had a larger volume in the better lumber grades and were inherently more valuable. That's why regression lines for grade 1 logs crossed near 300 board feet. Regression lines representing the least-squares fit for grade 2 logs did not cross because there were enough big sound logs to balance the high values received from the big unsound logs.

Now consider the unusual log-value relationship for the samples in log grade 3. Why did the average defective log have a higher net value than the average sound log? Differences were obviously not due to scaling inaccuracies or higher lumber production costs —otherwise the value relationships would have been reversed.

We believe that the larger diameters of the defective logs were partly responsible for the higher log values. Generally, the bigger the logs, the higher the proportion of lumber in the upper grades. The following tabulation substantiates this premise. Defective grade 3 logs with an average net volume of 202 board feet had 51 percent in 1 Common and Better lumber. Sound grade 3 logs with an average net volume of 158 board feet had 46 percent in 1 Common and Better lumber:

Lumber grade	*Sound logs (percent of yield)*	*Defective logs (percent of yield)*
FAS	6.2	13.2
IF	12.5	8.2
1 COM	27.2	29.3
2 COM	25.8	26.0
3A	18.8	13.1
3B	9.5	10.2

This particular sample of grade 3 logs was classified grade 3 primarily for one reason: the frequency and location of surface defects. On big logs, surface defects in the same face may be only 2 feet apart longitudinally. However, the sawyer may be able to cut some relatively clear boards between knots that are spaced far apart radially. That may be why the yield in the upper lumber grades was greater than the yield normally obtained from grade 3 logs. Furthermore, the log grade rules permit grade 2 logs with 51 to 60 percent cull to be classified as grade 3 logs even though the maximum cull deduction for grade 3 logs is 50 percent. This provision may be one reason why the defective grade 3 logs had a higher net value than sound grade 3 logs—some of the defective logs had grade 2 surface characteristics.

Elimination of Scaling Inaccuracies

Suppose that a company scaler and sawmill crew worked in such perfect harmony that there was no difference between the log scale and the lumber volume sawed. How would such a relationship affect the net value of the lumber sawed from sound and defective logs?

For the log sample used in this study, precision scaling would have increased net sawlog values. The value increase would have been about $1.55 per MBF for sound logs and about $3.70 per MBF for defective logs. Precision scaling also would have the effect of reducing some of the irregularities observed in our plot of sawlog dollar value over net scale. For example, some of the large sound logs would no longer be worth less than some of the unsound logs of equal net volume. Hence, regression lines representing sawlog dollar value over lumber yield (perfect log scale) show a more parallel relationship between sound and defective logs in the same grade.

Why would there be an increase in net log value from precision scaling? Under actual practice, the company scaler overestimated net volume in this group of logs. Therefore the company paid the logging contractor for more volume than they actually sawed. They also paid more for the stumpage. If both stumpage and logging had been paid for on the basis of the exact volume sawed, raw-material costs would have been less, and the resulting net log values would have been higher.

This example shows why millowners need to know the level of scaling accuracy practiced at their respective facilities. A consistent overestimate of net volume will require a downward price adjustment to keep raw-material costs in line. Of course, an underestimate of net volume has the opposite effect. Thus a consistent overrun permits owners to raise log-purchase price if stumpage competition and producers' harvesting costs require it.

POTENTIAL SAWLOG VALUES

For the final evaluation of sawlog value, we eliminated both the cost of delivered logs and the cost of lumber production as measured by sawing time. Thus the comparisons between sound and defective logs are based on the relationship between *net* lumber *volume* mill tally and *gross* lumber *value* per log. We have designated this association the board foot-dollar ratio.

The link between net lumber volume and gross lumber value per log represents an unreal situation. You cannot eliminate costs and get an accurate picture of individual log value. However, neither can you assess the inherent worth of a log if you base your evaluation of production costs on highly variable sawing times. Nor can you correctly evaluate potential sawlog worth if you use purchase prices that are based on inaccurate scale estimates. Therefore, to get a true measure of the *potential* value of a log, you

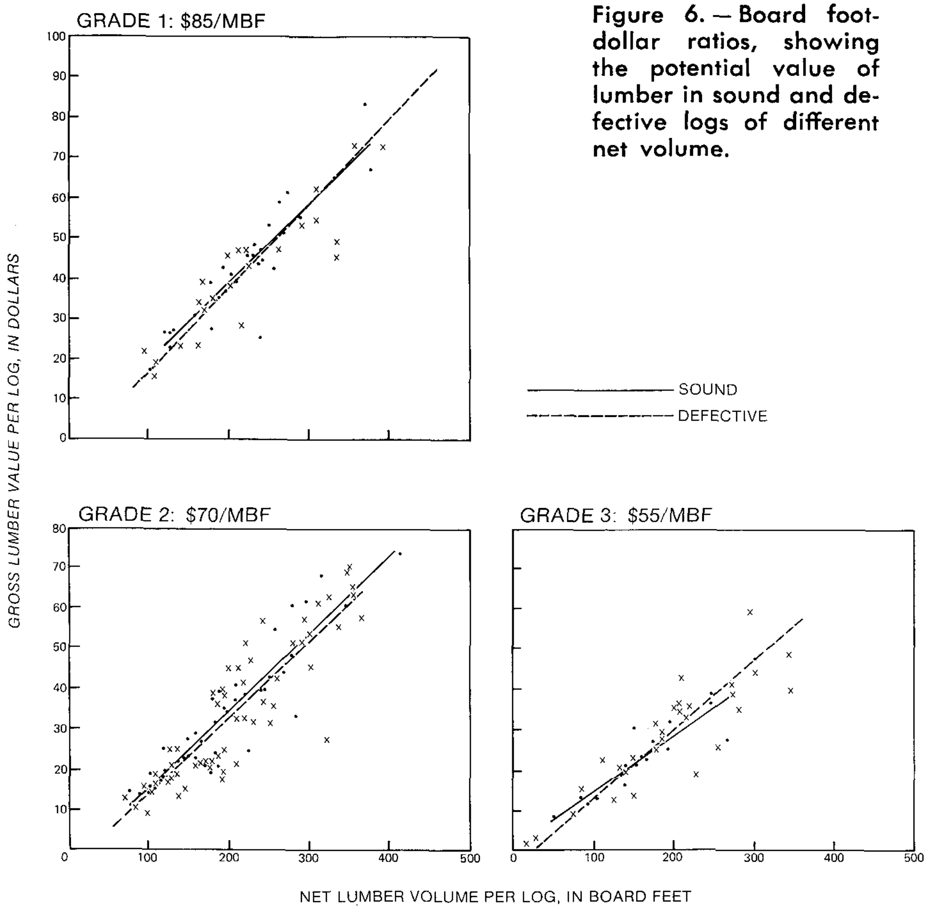


Figure 6. — Board foot-dollar ratios, showing the potential value of lumber in sound and defective logs of different net volume.

should use some evaluation technique like the board foot-dollar ratio.

The regression lines (fig. 6) illustrate the striking similarity in gross dollar value between sound and defective logs of the same grade. Apparently a given quantity of lumber sawed from a defective log is worth just as much money as an equivalent volume sawed from a sound log. When the ratio between gross dollar value and net lumber volume is expressed on a thousand-board-foot basis, the resemblance between sound and defective logs is conspicuous:

Log grade	*Sound logs*	*Defective logs*
1	$194	$192
2	172	164
3	144	152

In the foregoing tabulation, you will notice that sound logs in grades 1 and 2 had a slightly higher value than defective logs. In log grade 3, however, lumber from the defective logs was worth more. This value relationship corresponds closely with the log value associations observed under actual operating conditions.

Although the board foot-dollar ratios have no immediate practical significance, both lumbermen and researchers should be interested in the value associations. Mill operators will recognize that they can get just as good lumber from defective logs even though production is slower and more costly. Researchers, on the other hand, will be encouraged to seek for improved techniques for recovering this high-grade material that is now so frequently wasted.

SUMMARY

Lumbermen considering the use of internally defective butt logs should be prepared to face some of the technical questions that might arise when using such raw material. Millowners should understand how defective logs affect such operations as truckload volume, scaling precision, and sawing time. Then they can decide whether the net dollar yields from unsound logs will offset some of the special problems that will be encountered.

Trucking defective butts had little effect on the net scale per load. There was less than 10 board feet difference between loads of currently merchantable logs and loads containing both merchantable and defective logs. Thus hauling costs were unaffected by the acceptance of unsound butts.

Scaling precision on individual logs was extremely variable, regardless of log condition. Although overestimates and underestimates nearly balanced one another, underrun for the entire sample amounted to 1.7 percent for sound logs and 3.8 percent for defective logs. With this underrun, log costs per board foot of lumber yield were higher than expected. If the company scaler had been able to precisely estimate the actual net lumber yield, then the cost of delivered logs, including stumpage, would have been reduced about $1.55 per MBF for sound logs and about $3.70 per MBF for defective logs.

Sawing times for defective logs were noticeably greater than the sawing times for sound logs of similar size. Furthermore, the spread in sawing time between sound logs and defective logs was even wider when the comparisons were based upon an equivalent volume of lumber sawed from both types of logs. One minute more of headsaw time was needed to saw 100 board feet of lumber from defective logs than from sound logs. And 1½ minutes more of headsaw time were needed to saw 300 board feet of lumber. Naturally, the additional sawing time needed for equivalent lumber production from unsound logs sharply increased milling costs.

Net dollar yields from sound logs in grades 1 and 2 were higher than the net dollar values obtained from defective logs of similar volume and grade. The difference in net value between average sound and unsound logs was $1.50 for grade 1 logs and $5.00 for grade 2 logs. For grade 3 logs, however, the average unsound log was worth about $3.00 more than the average sound log.

The potential value of a given volume of lumber cut from either sound or defective logs was nearly identical. Thus, the dollar value of 1,000 board feet of lumber sawed from defective logs was approximately equal to the dollar value of the same quantity of lumber sawed from sound logs. But this similarity, called the board foot-dollar ratio, applies to gross value or selling price. Such an evaluation disregards production costs and scaling inaccuracies that influence raw-material costs. Nevertheless, the high inherent value of lumber in defective logs should tempt lumbermen to use more of this type of raw material rather than waste it.

■

LITERATURE CITED

1. Berry, Frederick H.
   1969. DECAY IN THE UPLAND OAK STANDS OF KENTUCKY. USDA Forest Serv. Res. Paper NE-126, 16 pp. NE. Forest Exp. Sta., Upper Darby, Pa.
2. Carvell, Kenneth L., and William R. Maxey.
   1969. WILDFIRE DESTROYS. W. Va. Univ., W. Va. Agr. and Forestry 2 (2): 3 pp., illus.
3. Church, Thomas W., Jr.
   1969. DON'T LEAVE YOUR DEFECTIVE MAPLE BUTTS IN THE WOODS. N. Logger 17(11): 24, 25, 39.
4. Deitschman, Glen H., and David E. Herrick.
   1957. LOGGING INJURY IN CENTRAL STATES UPLAND HARDWOODS. J. Forestry 55: 273-277.
5. Flann, Ian B.
   1969. TAKE A SECOND LOOK FOR HIDDEN VALUE IN HARDWOOD CULL LOGS. Canad. Forest Indus.: 28, 29, 31.
6. Meyer, Gene, John H. Ohman, and Russell Oettel.
   1966. SKIDDING HARDWOODS—ARTICULATED RUBBER-TIRED SKIDDERS VERSUS CRAWLER TRACTORS. J. Forestry 64: 191, 194-196.
7. Ostrander, M. D., and others.
   1965. A GUIDE TO HARDWOOD LOG GRADING. (revised). NE. Forest Exp. Sta., 50 pp., illus. Upper Darby, Pa.
8. Shigo, Alex L.
   1966. DECAY AND DISCOLORATION FOLLOWING LOGGING WOUNDS ON NORTHERN HARDWOODS. USDA Forest Serv. Res. Paper NE-47, 43 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

■

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.