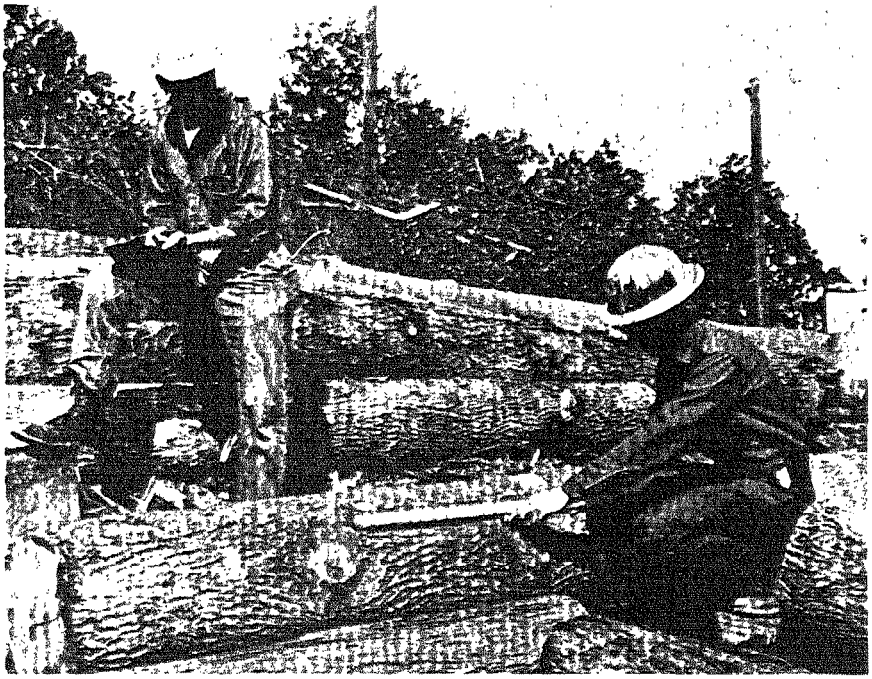
# The Cost of SCALING & GRADING Hardwood Sawlogs

by Thomas W. Church, Jr.



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# Foreword

HUNDREDS of articles have been written about log grading. Many of them extol the economic benefits that should accrue from the use of a log-grading system. Some lumbermen have heeded this advice and now use log grades to control the quality or species of logs delivered to their sawmills. Rarely, however, do these sawmill operators use a grading system that will provide an accurate estimate of lumber yield and quality. They think it would be too complex and too costly.

The purpose of this study reported here was to investigate one of these objections: the purportedly high cost of using a detailed grading system such as the U. S. Forest Service log grades. No published information was available, so it was necessary for us to investigate certain factors that we believed would have an important effect upon log-grading costs. Our study was designed to show how grading location, log size, crew size, and species influence both scaling and grading costs.

This paper describes experimental results and interprets these findings in terms of a practical application on Appalachian lumbering operations. All reference to statistical analytical procedures has been omitted from the text. However, scientifically oriented readers might be interested to know that results are based upon computer-programed regression techniques.

Since the basic sampling unit was 1,000 board feet gross log scale, Scribner rule, all results are reported in terms of this volume unit. To give you some measure of data variation: 9 times out of 10, the mean costs of scaling plus grading were within 10c per 1,000 board feet of the tabulated results. There was even less variation when grading costs were considered separately. In fact, for the same degree of confidence, average log-grading costs were within 2c per 1,000 board feet of the costs reported in the tables.

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## The Author

THOMAS W. CHURCH, JR. joined the 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 job at the Forest Products Marketing Laboratory in Princeton, West Virginia. Mr. Church has a Master's degree in forest utilization from Duke University.

## WHY NOT GRADE LOGS?

"WHAT would it actually cost me to grade my sawlogs?" This question is frequently asked by many lumbermen who understand the benefits of log grading but have not yet adopted a log-grading procedure. If these lumbermen knew that they could grade logs for as little as 25c per 1,000 board feet, they might be induced to adopt log-grading procedures.

Can logs be graded accurately for only 25c per 1,000? They certainly can. At many mills they can be graded for as little as 15c per 1,000 board feet. Of course grading costs depend upon the daily volume of logs graded, the size of the logs graded, and the skill and efficiency of the grader.

If there are 10 logs per 1,000 board feet, an experienced man can grade this volume in about 3 minutes. This is about four times faster than he could scale these same logs if he followed the detailed scaling procedures used by the U. S. Forest Service. He is able to grade this rapidly because scaling and grading are logically performed as an integral operation, and grading requires many of the same measurements that are used for scaling. Therefore grading is faster than scaling because a log may be partially or completely graded by the time it is scaled.

Log grades provide the raw-material quality control needed by most hardwood lumbermen. This has been repeatedly emphasized by such authorities as Carpenter (1953) and Lockard (1950). Furthermore, the advantages of using log grades, the techniques

of applying them, and the results of actual log-grading tests have been reported in more than 250 publications prior to 1955. Yet many sawmill operators still buy logs on a rudimentary grading system or by casual inspection alone. Why hasn't the Forest Service log-grading system been adopted?

Complex log-grading systems are rarely used: they are too costly and too difficult for loggers to understand. These are the reasons most frequently given when lumbermen are asked why they do not use a detailed grading system of proven accuracy. Many sawmill operators might prefer to use a precise grading system for factory logs such as the one developed by the U. S. Forest Products Laboratory (1953). But they believe that application of these complicated grade specifications would require extra men and thereby would increase total operating costs. Furthermore, they feel that log suppliers who do not understand the grading rules might believe that they are being cheated; and thus these suppliers might send their logs to nearby competitors who use simplified grades or none at all.

These objections are valid and must be faced by an operator who is considering the adoption of a detailed log-grading system. Problems related to the interpretation and understanding of a grading system can best be solved by a training program in which both log suppliers and log purchasers participate. But problems associated with grading costs are most appropriately attacked through a research study.

## THE STUDY

In the fall of 1964, the Forest Products Marketing Laboratory began a study of log-grading costs in the Appalachian Mountain region. Nine companies in West Virginia, one in Tennessee, one in North Carolina, one in Massachusetts, and one in Vermont cooperated with the Laboratory in the study. Records were taken for most of the major species of northern hardwoods and Appalachian hardwoods.

The primary objective of this study was to evaluate major factors that might affect the economics of scaling and grading hardwood

sawlogs. The four factors selected for evaluation were: (1) scaling and grading location, (2) log size, (3) grading-crew organization, and (4) species. Each of these variables was tested to determine its effect upon the time and cost of scaling and/or grading.

Although this study was designed primarily to investigate grading costs, scaling costs were also considered. Scaling and grading are normally performed as an integral operation because measurements of log size and the determination of scale defects have a direct effect upon log grade and quality. Therefore, in this study evaluations were made for grading costs and for scaling and grading costs combined.

## METHODS

All log-grade determinations were based on the grading system developed by the Forest Products Laboratory (1953). This system, adopted by the U. S. Forest Service as standard for hardwood factory logs, provides for volume and value estimates by species, log grade, lumber grade, and average log diameter. Recommended grading procedures were followed precisely in order to develop accurate time and cost data.

Logs were scaled according to the rules outlined in the National Forest Scaling Handbook (1964). Thus average scaling diameter was obtained from at least two measurements at the small end of the log, and net volumes were computed from scale deductions for both surface and internal defects. Tabular deductions for internal cull and sweep were posted on our scale sticks to facilitate net scale determinations. Even with these short cuts, we found that scaling took considerably longer than grading.

Some of the items used for grade evaluation such as log size, percentage of cull, and percentage of sweep were obtained from the log-scale measurements. So scaling actually provided some of the information needed for grading. If log grading were performed as a separate operation and not combined with scaling, then the time and cost of grading might be greater than the values reported in this paper.

Scaling and/or grading costs are based on an assumed hourly wage cost of $2.50 for a skilled scaler and grader. In addition to wages, this figure includes employer's payments for unemployment compensation, payroll taxes, and health and accident benefits. This cost is higher than many lumbermen may presently be willing to pay. But these are technical services that directly affect profit and loss, so we believe that this wage charge is not at all unreasonable.

Since our objective was to obtain scaling and grading costs per 1,000 board feet, we first had to measure time and then convert time to cost. Measurements of scaling and grading performance were made for 1,000-board-foot units on a Scribner-log-rule basis. Rarely did any of our 338 sample units scale 1,000 board feet. Therefore, in summarizing the field measurements, we adjusted all scaling and grading times to a 1,000-board-foot basis.

We recorded scaling plus grading time in man-minutes for each 1,000-board-foot unit. Total elapsed time for each sample unit included all scaling and grading activities plus any nonproductive time for walking between logs, staying clear of moving equipment, and other short-term delays. This total elapsed time did not include long-term delays due to equipment breakdowns or lack of sufficient logs to complete the sample unit.

Grading time was recorded by stop watch. It included the following operations: recognition, measurement, and assessment of log surface and end features affecting log quality; turning the log when necessary to determine the grading face; and consideration of such quality-controlling factors as diameter and sweep, which were calculated while scaling.

The variables tested in this study were as follows:

A. **Grading location:**
   1. In the woods. (a) At the stump. (b) At the landing.
   2. At the sawmill. (a) In the log yard. (b) On the mill deck.

B. **Log size:**
   1. Average scaling diameter per unit.
   2. Number of logs per 1,000 board feet.

C. **Crew organization:**
   1. One man.
   2. Two men.

D. Species:

1. Individual species: (a) Red oak, *Quercus rubra* L.; (b) White oak, *Quercus alba* L.; (c) Chestnut oak, *Quercus prinus* L.; (d) Beech, *Fagus grandifolia* Ehrh.

2. Species group: (a) Sugar maple, *Acer saccharum* Marsh, and Red maple, *Acer rubrum* L.; (b) Yellow birch, *Betula alleghaniensis* Britton, and Sweet birch, *Betula lenta* L.; (c) White ash, *Fraxinus americana* L.; and American basswood, *Tilia americana* L.; (d) Yellow-poplar, *Liriodendron tulipifera* L.; and Cucumbertree, *Magnolia accuminata* L.; and (e) Other hardwoods.

# RESULTS

## Minimum Scaling and Grading Costs

Records from nearly 350,000 board feet of logs showed that one man can scale and grade 1,000 board feet of logs in about 15 minutes. Approximately 3 minutes, or 20 percent of this time, was spent on actual grading. The remainder was needed for scaling, recording the scale and grade in the tally book and on the logs, walking between logs, and minor nonproductive actions. At this rate, a man could scale and grade 32,000 board feet per 8-hour day at a cost of 62½c per 1,000 board feet. (Cost based on wage charge of $2.50 per hour.) The actual cost of grading would be only 12½c per 1,000.

Can a man keep up this pace all day and still apply the scale and grade specifications accurately? We found that he could. In fact, his efficiency should improve with increased experience because the results reported in this study are based upon the performance of trained men who had only a few months of practical experience.

## Practical Scaling and Grading Costs

The scaling and grading costs mentioned in the preceding section are based on the assumption that a trained man is employed to perform these services. But the costs apply for only two situations: (1) where the scaler-grader constantly works to his maximum capacity of about 32,000 board feet per day, or (2) where

scaling and grading costs are charged as an expense item only for the time spent on these tasks.

Since most Appalachian sawmills cut less than 32,000 board feet per day, it is apparent that an experienced grader would not be busy all day. The question then arises, should a sawmill manager compute his scaling and grading charges per 1,000 board feet on the basis of the time actually spent appraising this volume, or should he base his unit scaling and grading costs upon the total daily wage cost regardless of the volume handled? We believe the latter alternative is the most reasonable method for computing unit scaling and grading costs even though it may not be a proper accounting procedure.

To substantiate this belief, let us assume that a sawmill owner decides to adopt the Forest Service scaling and grading system. He hires a technically trained man for this work and pays $2.50 per hour or $20 per day for these services. His sawmill produces about 16,000 board feet per day, so his average daily log receipts would be similar. Since the log grader can scale and grade this volume in about 4 hours, he would have half a day for other productive work.

But what other duties could this technician perform? The sawmill was probably efficiently staffed before he was hired, and certainly he would not be expected to perform menial odd jobs around the plant. Furthermore, log trucks do not arrive at regular intervals and the grader must always be ready to appraise logs as soon as they are delivered, or the mill yard will become cluttered. If the grader has other duties, these will have to be postponed while the logs are scaled and graded. These interruptions may seriously hinder the orderly sequence of production at the mill.

For these reasons, it is logical to expect that the grader will have only one assignment — to scale and grade the logs. Although he will not constantly be performing his assigned duties, his wages will continue regardless of the volume handled. Where this occurs, the sawmill operator should realize that his scaling and grading costs are influenced solely by the volume measured and appraised. Thus, the daily volume of logs available for scaling and grading significantly affects the cost of scaling and grading, as

shown in the following tabulation:

| *Daily volume scaled and graded (1,000 board feet)* | *Scaling and grading cost per 1,000 board feet*[1] |
|---|---|
| 8 | $2.50 |
| 10 | 2.00 |
| 15 | 1.33 |
| 20 | 1.00 |
| 25 | .80 |
| 30 | .67 |

[1] Based on a total wage cost of $2.50 per hour or $20 per 8-hour day.

## Grading Costs

Our observations showed that grading required 14 to 30 percent of the total time spent for both scaling plus grading. This wide range in grading time was due to difference in log size and grading location. Average grading time was 22 percent of the total scaling plus grading time. At this rate, the grading costs for many Appalachian mills would range from 15c to 55c per 1,000 board feet depending upon daily production rate. For an average mill sawing 15,000 board feet per day, the extra job of log grading would cost only 29c per 1,000 board feet.

The adoption and application of a detailed log-grading system will have little effect upon the quality of logs delivered to a mill unless there are economic benefits to both log producer and log consumer. Of course, the use of a log-grading system will not change sawlog quality. However, when prices for graded logs are commensurate with log value, the use of a grading system should affect the quality of logs delivered to a mill. Therefore, if log quality is to be improved by increasing the proportion of higher grade logs, then log prices will also have to be increased to compensate the log supplier for the unsalable logs and the cost of sorting.

## Location

The place at which scaling and grading was performed had little effect upon the time and cost of these combined functions when performed by a one-man crew. It was least expensive to scale and grade on the sawmill deck and most expensive at the

stump. There was almost no difference in cost between the mill yard and the landing. For a two-man crew, however, there was a substantial difference in cost between both the stump and landing and the other two locations. The following tabulation, based on average costs for all log sizes, shows these differences in scaling and grading cost per 1,000 board feet:

| *Location* | *One-man crew* | *Two-man crew* |
|---|---|---|
| Stump | $0.62 | $1.37 |
| Landing | .58 | 1.11 |
| Yard | .59 | .95 |
| Deck | .52 | .97 |

Location had even less influence upon grading costs than it had upon the combined costs of scaling and grading. Among the four locations examined in this study, there was a difference in average grading costs of only 2c per 1,000 board feet for a one-man crew and 5c per 1,000 board feet for a two-man crew. Thus, location had an insignificant effect upon grading cost — especially when all log sizes and species were grouped.

Of course these results are based on our experimental techniques, in which log volume at any location was assumed to be unlimited. In actual practice, we believe it will be considerably less costly to scale and grade at the mill than in the woods. Not only are more logs available at the mill than at any woods landing, but they are more easily and safely scaled and graded. Rarely will any sawmill receive all its logs from one source: therefore logs can be scaled and graded more cheaply at the mill than at the landings or the stump because only one scaler-grader is needed.

Should logs ever be graded and sorted at the landing so that logs of various quality may be loaded and trucked directly to mills processing a specific grade? Yes — but only where one scaler-grader is needed to evaluate the total daily log requirements of any one mill. If more than one scaler-grader is needed to service several landings, then it may be cheaper to haul all grades to the principal sawmill. Of course, both the question posed and the answer provided assume that there are separate market outlets for different grades of hardwood sawlogs. At present such diversification is extremely rare. If such a practice should become more

common, we believe that it would be more expensive to have extra graders at the landings than to truck all logs to the primary mill, grade them and then reload and haul the low-grade logs to a second mill. However, more research is needed to show what system would be most efficient.

Occasionally it may be advantageous to scale and grade at the landing. Some of the advantages may be indirect. Loggers would be more inclined to buck for the highest quality if a grader were stationed at the landing. In fact, the grader might even mark the location of the bucking cuts and thereby improve log quality. For some Appalachian lumbermen, however, it would be inadvisable to scale and grade at the landing. In rugged terrain, a grader will seldom evaluate log quality at more than one landing daily because as soon as tree lengths are bucked, they are pushed aside to make room for the next hitch of tree lengths or to allow passage of log trucks. Therefore more than one grader would be needed and costs would increase.

Although scaling and grading costs are least on the sawmill deck, we believe that the mill yard affords the most advantages (figs. 1 to 3). These advantages are (1) greater ease, safety, and accuracy of scaling and grading through use of mechanical log-handling equipment; (2) immediate scale and grade for trucker and log contractor as basis for weekly payment; (3) possible resale of low-grade factory logs to a local mill specializing in ties, timbers, and industrial products; (4) less noise, dust, and danger than on the sawmill deck; (5) greater opportunity for sawing efficiency when sorting and stacking by grade as well as by species; and (6) more efficiency than would be possible with woods scaling and grading because of the greater volume processed daily.

It is implied above that the use of mechanical log handling equipment would improve the efficiency and accuracy of log grading. No tests were made to prove this statement nor were any grading costs assigned for the use of this equipment. From our observations, some Appalachian sawmill operators have both the time and space to spread out the logs for better grading. In fact, one of our study cooperators uses this technique and is well pleased with it. Since he sorts each truck load and decks logs by


Figure 1.—Some companies scale logs on the truck. This practice is not advisable because the scaler must climb the load to make accurate diameter measurements. Furthermore, he cannot measure diameter or assess end defects of logs placed tight against the headboard. Grading logs on trucks is also inadvisable because important surface features are obscured and accurate quality evaluations cannot be made.

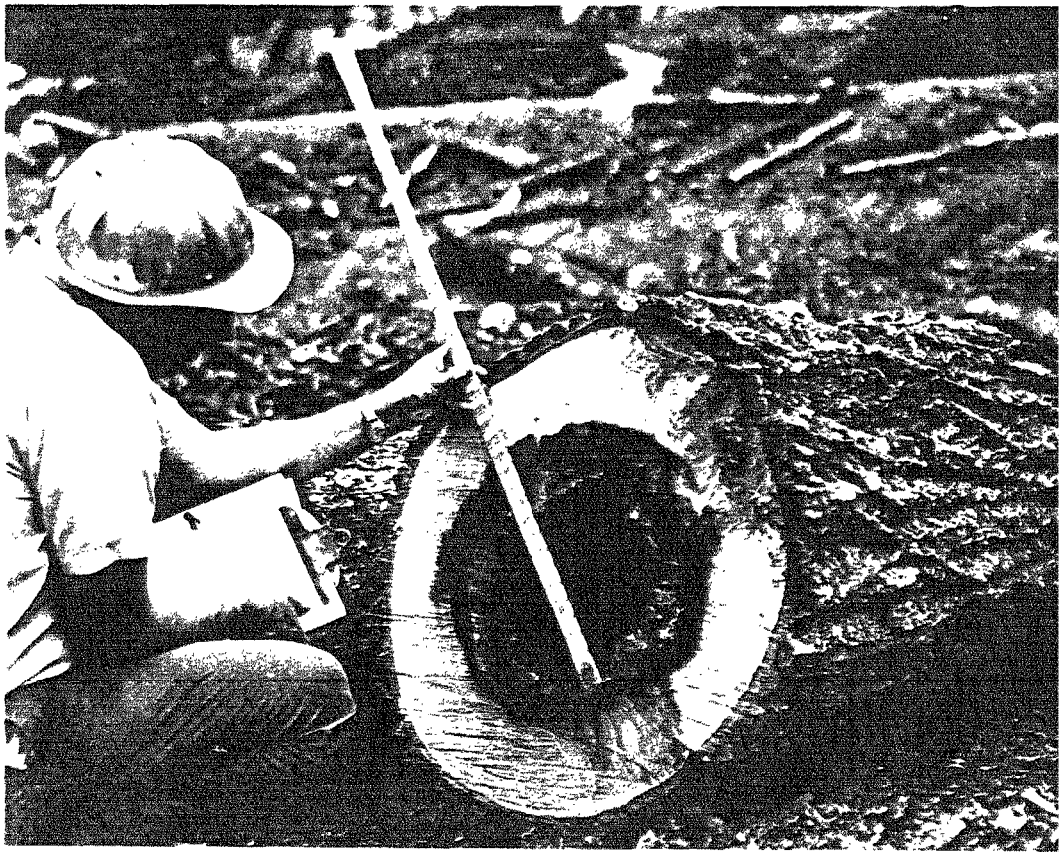
species, he is evidently unconcerned about the small extra cost of using this equipment to improve scaling and grading — especially since it does not delay any facet of his milling operation.

## Log Size

Average log size had a significant but inverse affect upon scaling and grading costs. As average log size increased, scaling and grading cost per 1,000 board feet decreased. This relationship is quite credible because scaling and grading time per log is relatively constant regardless of log size or volume. Therefore, the larger the log, the fewer the number of logs per 1,000 board feet, and the lower the costs per unit of volume.

Number of logs per 1,000 board feet provided a better measure of scaling and grading costs than did average scaling diameter.

Figure 2. — Logs should be scaled and graded on the ground, where accurate volume and quality assessments can be made.



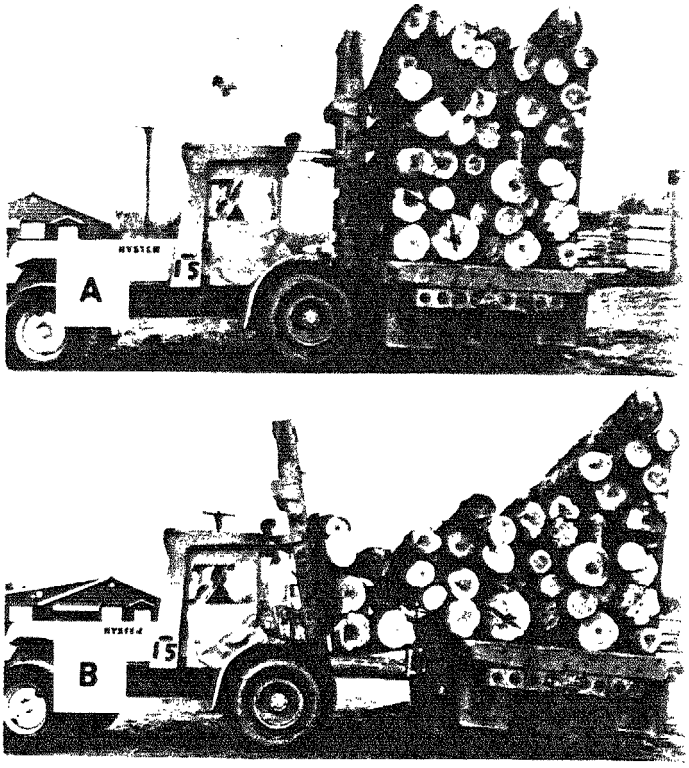
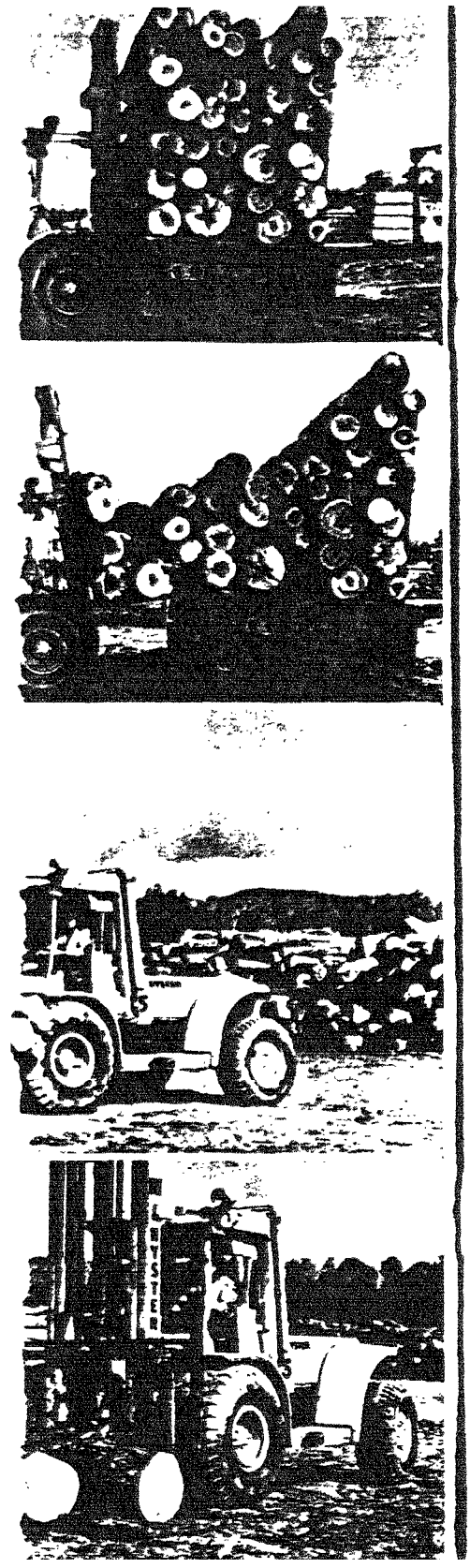




Figure 3.—Where space permits, logs should be spread out in the mill yard for accurate, safe, and economic scaling and grading. One company uses the following technique. (**A**) Lift truck forks are placed under the logs and the stakes are removed from one side of the truck. (**B**) As the lift truck backs up, the logs roll onto the forks. (**C**) The lift truck spreads the logs in an unobstructed yard area by tilting the forks forward and moving rapidly in reverse. (**D**) The logs are spaced for efficient scaling and grading and then are removed for sawing or decking.



This evaluation was substantiated by our statistical analysis. For nearly every combination of log size, crew size, and grading location, regressions based upon number of logs per 1,000 board feet gave more precise results than did regressions based upon scaling diameter. Some people may object to our practice of definitively equating log size with number of logs per 1,000 board feet. However, we believe this is both technically sound and desirable because the number of logs per unit of volume incorporates length as well as diameter.

Log size had a more pronounced effect upon scaling and grading costs at the stump than it did at the other locations tested (tables 1 and 3). Except for sampling units comprised of large logs, more time was required to scale and grade a 1,000 board-foot unit of logs in the woods because of the time spent walking between logs. In the woods, therefore, scaling and grading costs were influenced by the physical placement of the logs as well as by the average size of the logs.

For a one-man crew, log size had an even stronger influence upon grading costs than it did upon scaling plus grading costs. The same trends prevailed: grading costs increased with a concomitant increase in number of logs per unit of volume. At most

**Table 1. — Effects of log size and location upon the time[1] and cost[2] of scaling and grading 1,000-board-foot units with a 1-man crew**

| Average log size (No. logs per 1,000 board feet) | Scaling and grading location | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Stump | | Landing | | Yard | | Deck | |
| | Time | Cost | Time | Cost | Time | Cost | Time | Cost |
| | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* |
| 6 | 8.8 | 0.37 | 10.2 | 0.42 | 9.2 | 0.38 | 10.1 | 0.42 |
| 8 | 12.5 | .52 | 12.6 | .52 | 12.4 | .52 | 11.6 | .48 |
| 9 | 14.4 | .60 | 13.6 | .57 | 13.9 | .58 | 12.3 | .51 |
| 10 | 16.2 | .68 | 14.6 | .61 | 15.0 | .62 | 13.1 | .54 |
| 11 | 18.0 | .75 | 15.4 | .64 | 16.1 | .67 | 13.8 | .57 |
| 12 | 19.8 | .82 | 16.0 | .67 | 17.1 | .71 | 14.5 | .60 |
| 14 | 23.6 | .98 | 17.3 | .72 | 18.4 | .77 | 16.0 | .67 |

[1] Based on elapsed clock time for 140 thousand-board-foot units at 11 companies in 6 states.
[2] Based on wage rate of $2.50 per hour.

**Table 2. — Effects of log size and location upon the time[1] and cost[2] of grading 1,000-board-foot units with a 1-man crew**

| Average log size (No. logs per 1,000 board feet) | Grading location | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Stump | | Landing | | Yard | | Deck | |
| | Time | Cost | Time | Cost | Time | Cost | Time | Cost |
| | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* |
| 6 | 1.3 | 0.05 | 2.6 | 0.11 | 1.9 | 0.08 | 1.9 | 0.08 |
| 8 | 2.2 | .09 | 3.1 | .13 | 2.6 | .11 | 2.6 | .11 |
| 9 | 2.7 | .11 | 3.3 | .14 | 2.9 | .12 | 3.0 | .12 |
| 10 | 3.1 | .13 | 3.4 | .14 | 3.2 | .13 | 3.3 | .14 |
| 11 | 3.5 | .15 | 3.5 | .15 | 3.6 | .15 | 3.7 | .15 |
| 12 | 4.0 | .17 | 3.5 | .15 | 3.9 | .16 | 4.0 | .17 |
| 14 | 4.9 | .20 | 3.5 | .15 | 4.6 | .19 | 4.8 | .20 |

[1] Based on elapsed clock time for 140 thousand-board-foot units at 11 companies in 6 states.
[2] Based on wage rate of $2.50 per hour.

grading locations, the cost of grading a unit of 14 logs per 1,000 board feet was 2½ to 4 times greater than that for a unit of 6 logs per 1,000 board feet (table 2).

For a two-man crew, the effect of log size upon grading time was not so pronounced (table 4). In fact, log size had no influence on the rate at which a two-man crew could grade logs in the woods or on the sawmill deck. Evidently there were insufficient samples to show a trend.

None of the tables presented in this paper accurately illustrate the true effects of log size upon grading time. The tabular data are based on field samples and these 1,000 board-foot units are frequently a composite of widely different log sizes.

When log size and grading time are analyzed independent of random sample occurrence, a different pattern emerges. A 1,000-board-foot unit of logs measuring 8 to 10 inches in diameter can be graded just about as rapidly as a similar volume of logs measuring 23 inches in diameter or larger. This apparent anomaly is due to the grading specifications used: most logs under 11 inches are automatically grade 3 if they meet other broad standards of sweep, cull, and defect placement. Therefore it takes very little

time to grade them. But for logs 11 inches in diameter and larger, there are several possible grades and more specifications to consider; so grading immediately becomes more time-consuming. The relationship between log diameter and grading time are shown in the following tabulation:

| *Log diameter (inches)* | *Grading time (man-minutes per 1,000 board feet)* |
|---|---|
| 8-10 | 1.0 |
| 11-13 | 5.3 |
| 14-16 | 3.4 |
| 17-19 | 2.5 |
| 20-22 | 1.7 |
| 23+ | 1.1 |

Our observations showed that log size had one other obvious effect on grading costs, and this occurred solely at the landing. At the landing, there was only a slight increase in grading cost with a substantial increase in the number of logs per 1,000 board feet. In fact, there was no change in grading cost for samples with more than 11 logs per 1,000 board feet (table 2).

There is a logical explanation for this relationship. When tree lengths are skidded and bucked at the landing, the logs still occupy the same relative position that they had in the tree before

**Table 3. — Effects of log size and location upon the time[1] and cost[2] of scaling and grading 1,000-board-foot units with a 2-man crew**

| Average log size (No. logs per 1,000 board feet) | Scaling and grading location | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Stump | | Landing | | Yard | | Deck | |
| | Time | Cost | Time | Cost | Time | Cost | Time | Cost |
| | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* |
| 6 | 24.5 | 1.02 | 17.9 | 0.75 | 16.1 | 0.67 | 18.5 | 0.77 |
| 8 | 29.5 | 1.23 | 23.8 | .99 | 20.2 | .84 | 21.3 | .89 |
| 9 | 31.9 | 1.33 | 26.1 | 1.09 | 22.0 | .92 | 22.8 | .95 |
| 10 | 34.5 | 1.44 | 28.0 | 1.17 | 23.7 | .99 | 24.0 | 1.00 |
| 11 | 36.8 | 1.53 | 29.3 | 1.22 | 25.3 | 1.05 | 25.5 | 1.06 |
| 12 | 39.3 | 1.64 | 30.3 | 1.26 | 26.7 | 1.11 | 26.9 | 1.12 |
| 14 | 44.2 | 1.84 | 30.7 | 1.28 | 29.1 | 1.21 | 29.8 | 1.24 |

[1] Based on elapsed clock time for 198 thousand-board-foot units at 7 companies in 4 states.
[2] Based on wage rate of $2.50 per hour.

Table 4. — Effects of log size and location upon the time[1] and cost[2] of grading 1,000-board-foot units with a 2-man crew

| Average log size (No. logs per 1,000 board feet) | Grading location | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Stump | | Landing | | Yard | | Deck | |
| | Time | Cost | Time | Cost | Time | Cost | Time | Cost |
| | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* | *Min.* | *$* |
| 6 | 7.6 | 0.32 | 4.5 | 0.19 | 4.7 | 0.20 | 6.7 | 0.28 |
| 8 | 7.6 | .32 | 6.5 | .27 | 5.8 | .24 | 6.7 | .28 |
| 9 | 7.6 | .32 | 7.2 | .30 | 6.3 | .26 | 6.7 | .28 |
| 10 | 7.6 | .32 | 7.9 | .33 | 6.8 | .28 | 6.7 | .28 |
| 11 | 7.6 | .32 | 8.3 | .35 | 7.4 | .31 | 6.7 | .28 |
| 12 | 7.6 | .32 | 8.6 | .36 | 7.9 | .33 | 6.7 | .28 |
| 14 | 7.6 | .32 | 8.6 | .36 | 9.0 | .38 | 6.7 | .28 |

[1] Based on elapsed clock time for 198 thousand-board-foot units at 7 companies in 4 states.
[2] Based on wage rate of $2.50 per hour.

being bucked. The butt log is graded first, then the upper logs from the butt up. Both surface and internal defects found in the lower logs frequently recur in the upper logs of the same tree. This tendency for important log-grade characteristics — such as bumps, bird peck, stain, and seams — to occur in several logs of the same tree should make log grading faster and cheaper. However, at the landing, logs are frequently jammed together. In order to see more than 2 faces, it is often necessary to roll the log, and this is difficult and time-consuming because of space limitations and soil conditions. For this reason, any advantage of continuous tree grading at the landing is lost because of the extra time required to observe surface characteristics on hidden faces. Therefore differences in grading time due to log size are reduced because the bigger logs are more difficult to turn than the smaller logs.

## Crew Size

We found that one man could scale and grade almost as rapidly as a two-man crew. Occasionally one man could scale and grade more volume than a two-man crew during the same elapsed time.

Thus scaling and grading cost per 1,000 board feet was considerably lower with a one-man crew than with a two-man crew. Tables 1 through 4 illustrate this: both the time and cost of scaling and/or grading with a two-man crew were higher than the corresponding time and cost for one man with comparable log sizes and grading locations.

Some companies employ a two-man scaling crew, and there are situations where such a crew functions more efficiently than a one-man crew. If logs are scaled in decks or in truck-load piles, two men are necessary because both ends of individual logs must be identified if the logs are to be scaled accurately (fig. 4). However, logs should not be graded in piles or decks: they should be exposed for proper evaluation of surface defects. Therefore the advantages of a two-man scaling crew do not apply to log grading.

The inefficiencies of our two-man scaling and grading crew in this study compared to our one-man crew may have been due to the operating procedures that we used. Although one man scaled while the other graded, each performed certain measurements and calculations that were mutually beneficial. For instance, both men measured log-end diameters simultaneously. The scaler immediately recorded gross volume while the grader measured the sweep or the scale defects that occurred on his end of the log. He conveyed this information to the scaler, who in turn gave the grader the measurements of any grade defects on the scaler's end of the log.

Each man then completed his task of scaling and grading. The grader usually finished first. He then waited for his partner so they could work together on the next log. This inactivity for one man increased the time and cost of scaling and grading with a two-man crew. Reorganization of task assignment might improve the performance of a two-man crew. But it is extremely doubtful that two men working as a crew can scale and grade as efficiently as one.

## Species

Tree species did not significantly affect grading time. Differences in average grading time among the nine species tested did not

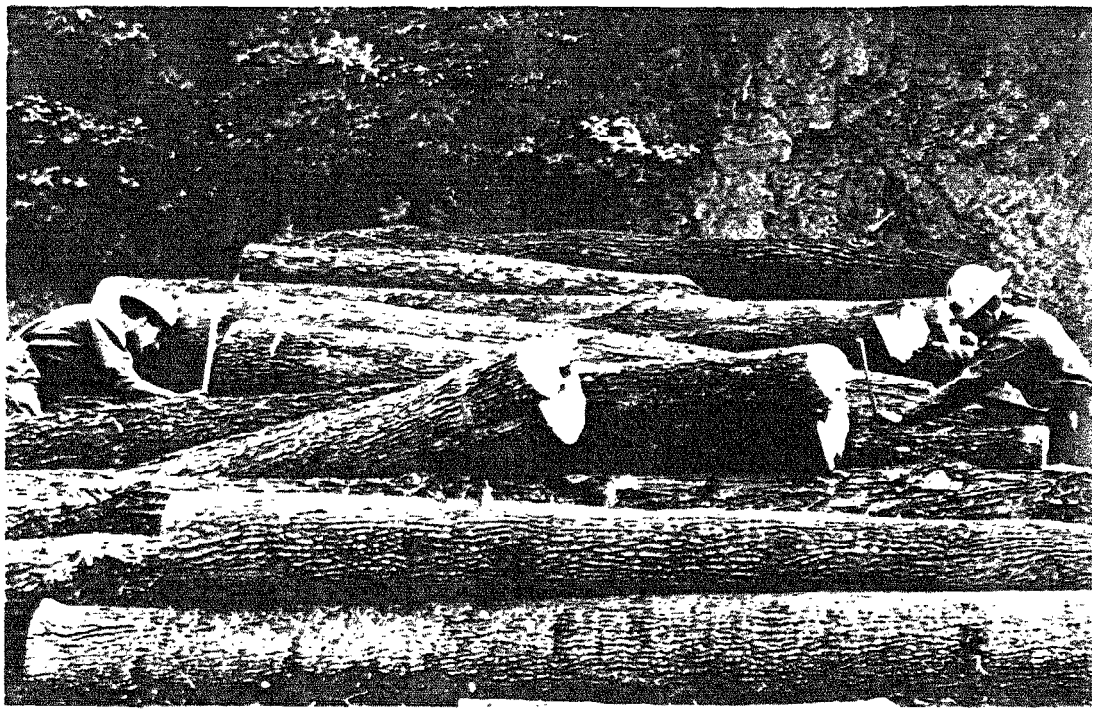


Figure 4.—When logs are scaled in piles or large decks, two men are needed for efficient and precise volume determination. However, logs cannot be accurately graded in these piles or decks because surface characteristics are obscured.

exceed 1 man-minute per 1,000 board feet. Thus, the variation in average grading cost due to species was less than 5 cents per 1,000.

When this study was designed, we thought that species might affect the time and cost of log grading because of inherent characteristics such as persistent limbiness and susceptibility to bird peck. But we found that species characteristics had very little effect: It was still necessary for us to scrutinize every log for obscure grade defects.

Of course, there were a few wider variations in grading time between species within a particular diameter class. But these deviations never exceeded 2 man-minutes per 1,000 board feet. In fact, within any of the six diameter classes tested, species grading times were uniform (table 5).

Table 5.—Average grading time by species and diameter class, in minutes per 1,000 board feet

| Species | Diameter class — inches | | | | | | Average all diameters[1] |
|---|---|---|---|---|---|---|---|
| | 8-10 | 11-13 | 14-16 | 17-19 | 20-22 | 23+ | |
| Red oak | 0.9 | 5.3 | 3.3 | 2.6 | 1.7 | 0.8 | 3.0 |
| White oak | 1.6 | 5.2 | 2.8 | 1.8 | 1.9 | 1.5 | 2.3 |
| Chestnut oak | .6 | 6.4 | 3.1 | 1.9 | 2.0 | 1.8 | 2.8 |
| Beech | 1.5 | 5.0 | 3.5 | 2.6 | 1.8 | 1.4 | 3.1 |
| Birch | 0 | 5.4 | 4.3 | 2.1 | 1.6 | .5 | 3.2 |
| Maple | 1.2 | 5.5 | 3.8 | 2.7 | 1.9 | 1.4 | 3.3 |
| Ash-basswood | 1.6 | 5.7 | 3.2 | 2.1 | 1.6 | .4 | 3.3 |
| Poplar-cucumber | .8 | 4.6 | 3.0 | 2.3 | 1.0 | 0 | 3.0 |
| Other hardwood | .3 | 5.0 | 3.5 | 2.7 | 1.2 | 1.1 | 3.3 |

[1] Averages based on grading time weighted by volume within each diameter class.

## SUMMARY

Hardwood logs can be graded inexpensively without hindering either woods or sawmill production schedules. Grading costs for most Appalachian and New England lumbermen will range from 15c to 55c per 1,000 board feet, depending upon the volume graded daily. For daily production rates of 30,000 board feet and 8,000 board feet, the respective costs of scaling and grading will range from 67c to $2.50 per 1,000 board feet.

Detailed records from nearly 350,000 board feet of hardwood sawlogs indicate that for a sample of logs averaging 10 per 1,000 board feet, scaling and grading require about 15 man-minutes per 1,000 board feet. Grading requires about 20 percent of the total or 3 man-minutes per 1,000.

Both the time and cost of scaling and grading — assuming an unlimited log supply — are influenced by such factors as average log size and crew size. Scaling and grading costs for 1,000 board feet are 1½ to 2½ times greater for small logs averaging 14 per 1,000 board feet than they are for large logs averaging 6 per 1,000 board feet. Grading costs are 2½ to 4 times greater for the smaller logs except those below 11 inches in diameter. Crew size is also important: one man was found to be nearly twice as efficient as a two-man crew.

Under practical conditions representative of many Appalachian hardwood operations, a scaler-grader will rarely work up to his daily capacity of 32,000 board feet. Therefore, scaling and grading costs per 1,000 board feet are more a function of the daily volume processed than a function of log size. In this situation grading location is important because the volume scaled and graded is influenced by the quantity of logs available.

Although logs can be scaled and graded at lowest cost on the sawmill deck, this is not the best place to grade logs. A prerequisite for efficient grading is a location where a grader can see and handle logs in an unhurried atmosphere. We believe the mill yard offers the most advantages: (1) there is a greater concentration of logs than in the woods or at the landing; (2) there is an opportunity for sorting logs by grade and sawing or selling certain grades to improve sawmill efficiency; (3) there is less noise, confusion, and danger than on the sawmill deck; (4) there is usually room to temporarily disperse the logs for better visibility and more accurate grading; and (5) there is power equipment available to move the logs easily and safely for greater scaling and grading efficiency.

With daily log-appraisal costs fixed, the factors that have the greatest practical influence upon scaling and grading costs are: (1) the crew size and (2) the volume of logs available, as determined by location. Average log size is important only when the scaler-grader works close to his daily capacity. Species is unimportant because inherent tree characteristics have no significant influence upon the time and cost of grading.

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