USDA

United States
Department of
Agriculture

Forest Service

Northeastern Research Station

General Technical Report NE-334

Continuous Sawmill Studies: Protocols, Practices, and Profits

Robert Mayer
Jan Wiedenbeck

Abstract

Ideally, the sawmill manager knows what he/she should pay for each sawlog and what profit to expect from each log of a given species, diameter, length, grade, and quality. In reality, hardwood sawmill managers seldom base sawlog prices on the log's profit potential. Rather, they tend to base raw material price on what they must pay to compete with those seeking the same material. In many cases, logs are processed at severe losses. The conventional sawmill study typically has been conducted on a substantially similar "batch" of logs to gain insight into gross (volume) yield, grade yield, and profitability for those logs. Traditional mill studies capture data over an abbreviated time span of only a day or two. Instead, mill study data should be collected continuously so that the results reflect potential profitability for a broad range of operating conditions. Alternate study approaches and specific mill study jobs are described and tools are provided for conducting sawmill studies. In today's global economy, the opportunity cost associated with suboptimal utilization of raw material and mill resources is substantial. As a result, understanding the profit potential associated with different types of logs is critically important for sawmill survival.

The Authors

ROBERT MAYER is a consulting forester and sawmill specialist in Indiana. He formerly was vice president of operations for a major hardwood sawmill. JAN WIEDENBECK is a Project Leader and research scientist with the USDA Forest Service's Northeastern Research Station at Princeton, West Virginia.

Acknowledgments

Funding for this study was received from the Wood Education Resource Center (WERC), Princeton, West Virginia. WERC is a unit of the USDA Forest Service's Northeastern Area, State and Private Forestry. We especially thank Al Steele of WERC for his interest and involvement in this project. The following reviewers provided excellent feedback and additional content suggestions that enhanced this publication: Paul Frederick, Vermont Department for Forests, Parks & Recreation; Jim Whipple, Wisconsin Department of Natural Resources; Patrick Rappold, Virginia Polytechnic Institute and State University; Chris Jennings, Colorado State Forest Service; and Dave Nicholls, Pacific Northwest Research Station. We also acknowledge valuable contributions from Steve Peskar, David Cannon, and Greg Gambrel, Georgia Pacific and Allegheny Wood Products, Inc.

Manuscript received for publication 8 March 2005

Published by:
USDA FOREST SERVICE
11 CAMPUS BLVD SUITE 200
NEWTOWN SQUARE PA 19073-3294

September 2005

For additional copies:
USDA Forest Service
Publications Distribution
359 Main Road
Delaware, OH 43015-8640
Fax: (740)368-0152

Visit our homepage at: **http://www.fs.fed.us/ne**

Contents

Mill Studies: An Overview

Sawmillers wish everyday was a good day. But winter means frozen logs and air lines, sluggish hydraulics, and potential machinery breakdowns. Spring can bring mud, dirty or half frozen logs, or even a log shortage. Summer and autumn bring their limitations: lumber stain, reduced employee productivity, and absenteeism. Sawmill managers recognize the wide variation in productivity and profitability levels between good days and bad days. Good days witness high machine utilization, increased lumber production, optimal lumber grade retrieval, and profitability. Bad days usually entail considerable downtime and associated decreases in production, lumber grade, and profits. The sawmill manager takes the good with the bad, presses on, and hopes the composite net result is acceptable production and associated profitability.

An optimally performing sawmill has mostly good days, and profit on these days is enhanced by the processing of "good logs." Even on the best of days, a perceptive manager recognizes that certain "ideal" logs yield higher profits than "lesser" logs. The increased profitability from these ideal logs may be associated with low purchase cost, preferred species, lack of defect, cleanliness, roundness, and other attributes. The actual profitability associated with these logs probably is not quantified but rather is based on an intuitive "gut" sense of profitability derived from experience. Lesser logs may have poor profitability due to factors such as excessive purchase price, undesirable species, hidden defects, or other negative attributes. As with the ideal log, the lesser log's lumber product value is seldom quantified; rather it is based on experience—an innate understanding derived from thousands of observations. The manager of the optimally performing sawmill knows what he/she should pay and what profit to anticipate from each log of a given diameter, length, species, grade, cost, and quality.

In reality, hardwood sawmills seldom base sawlog prices on yield and associated profit. Rather, they tend to base the raw material price on what they must pay to compete with those seeking the same material. In many cases, logs are processed at severe losses. Fortunately, logs that are processed at extreme profits moderate these losses. Although the bottom line shows a profit, it is a composite that has been diminished by losses incurred in sawing nonprofitable and less profitable logs. Profit is further eroded by the opportunity cost associated with processing no- or low-profit logs when more profitable logs could be occupying mill resources.

We know that a mill cannot buy only the "ideal" and "good" logs for their mill and their unique lumber market demands. But, if you knew that certain types of logs always processed at a loss and that the loss level was defined, would it not be advantageous to resell (merchandise) those logs at a loss so long as the loss was less than the loss incurred if the logs were processed in your mill? During this era of extreme log cost, rising production costs, and stagnant lumber prices, knowing the most profitable log mix and the optimal operating schedule is the key to a hardwood sawmill remaining profitable.

A sawmill study means different things to different people. The conventional "batch study" typically was conducted to gain insight into gross (volume) yield, grade yield, and profitability of a substantially similar "batch" of logs. Traditional mill studies capture data over an abbreviated time span of a day or two. While the data gathered and subsequent results are excellent indicators of specific yield and values, they may not reflect yields and values for:

- The full spectrum of species processed.
- The full spectrum of log sizes processed.
- Different processing methods (e.g., quarter vs. grade sawn).
- Different seasons of the year.
- Different operating shifts.
- Changes in mill personnel.
- The range of variation within a company log grade.
- The range of log variation from different regions.
- The range of log variation from different log suppliers.
- The range of log variation procured by different company timber/log buyers.
- The range of log variation from "in house" log graders.

- The range of log variation over time.
- The full range of market conditions (as this affects lumber thicknesses cut).

In short, the information from a batch mill study does not provide quantitative results with the accuracy necessary to make critical decisions affecting mill operations—in particular, those decisions affecting the purchase of raw materials. The astute mill manager recognizes that these sources of variation are important and seeks accurate, current information on how they affect profit. For the sawmill that operates more than one sawing system (e.g., scragg and band headrigs), information collected from both (all) systems can provide insight into which logs are processed most profitably through the two "sides" of the mill.

Continuous Sawmill Study

Ideally, mill study data should be gathered continuously while simultaneously focusing on defined, statistically significant log sample sizes. The results of a continuous sawmill study will reflect conditions and profitability under all operating conditions and regimes. This is accomplished by tracking individual logs and correlating processing costs, profit (or loss) levels, lumber grades, and yields with specific logs. This can be done with minimal impact on personnel and material flow.

A continuous sawmill study can define the price, *at a specific desired profit level*, that a *specific* sawmill should pay for a particular log of defined species, mill log grade, diameter, and length. Even relatively simple changes within a mill, such as changing the head sawyer or edger man, can result in significant changes in the mill's production and grade yields. Due to the large variation in hardwood sawmills, generic benchmarks for profitability, costs, prices paid for logs, etc., cannot be referenced reliably. Thus, each mill must be analyzed on the basis of its unique parameters.

"Continuous sawmill study" does not imply a nonstop process. Rather, it implies that relatively small bits of critical log, processing, and lumber yield data are collected on a continuous basis as time and staffing permits. In other words, at one point, little or no study information might be gathered due to severe personnel or market pressures, but the process resumes when feasible. Because data are collected over a long period, they more closely reflect a broad range of physical, market, and personnel conditions. Sufficient data must be collected so that statistically significant estimates of critical operating factors can be made (e.g., profit per log for different logs).

Know Your Operating Cost

A comprehensive Continuous Mill Study (CMS) requires precise financial and operational information to accurately determine the mill's total operating cost. Operating costs include both fixed and variable costs. Mill managers are well aware that today's modern sawmill is a costly venture. In fact, operational costs are second only to the cost of raw material. Logs, the sawmill's principal raw material, can account for as much as 65 percent of the cost of goods (green lumber) sold.

Total hardwood sawmill operational costs (exclusive of drying or other value-added manufacturing costs) typically range from about $4.50 per minute to more than $20 per minute due to differences in mill size and technological sophistication (capital investments). The concept of operational costs is a simple one when one understands that the longer the log stays in the mill, the more the boards produced from that log cost to produce. Operational costs accrue when the mill is running, including periods of downtime and reduced productivity. They are constant unless there is a change in staffing, machinery, or factors such as utilities, administrative costs, and employee benefits.

Operational costs are not an indication of profitability. A sawmill that is extremely costly to operate can be highly profitable by virtue of its ability to produce a high lumber volume per unit of time. Conversely, a sawmill with a low operating cost can operate at a loss if it fails to produce a sufficient volume of lumber. In some mills, the lumber yield might be high but profits will be reduced if the percentage yield of higher lumber grades is unusually low. Strategic purchases of raw material, controlled operational costs, and efficient retrieval of the highest potential grades of lumber over a calculated operating period ensure profitability.

The long-term success of any hardwood sawmill requires the utilization of an effective cost management system. A well-designed cost management system can provide sawmill managers critical information for successfully planning and controlling their sawmill's operations. When cost data on sawmill activities are collected and analyzed, managers can refine daily operational activities in ways that reduce costs and improve efficiency, and as a result, increase profitability.

Having accurate information on operating costs is necessary for calculating specific profitability among defined log classes. Fortunately, calculating a mill's operating cost is relatively easy using USDA Forest Service software entitled COST (Cost Of Sawing Timber).[1] A stand-alone companion of the SOLVE-2003 sawmill study computer program (Wiedenbeck and Dwyer 2000), COST is designed to calculate the per-minute cost of a specific sawmill operation. This value is then entered into SOLVE-2003, which provides a comprehensive analysis of sawmill recovery, efficiency, and profitability per log. When using COST, the user must gather and enter sawmill operational and cost information. The final analysis helps sawmill managers identify and solve potential problems before they become unmanageable. COST inputs can be adjusted so that users can explore the cost effects of operational and financial changes. To obtain a free copy of COST, contact the USDA Forest Service in Princeton, West Virginia, by telephone (304-431-2700) or visit our web page: http://www.fs.fed.us/ne/princeton/.

Specific Benefits

Previous discussions outlined the general benefits of mill studies. A CMS also provides the following:

1. "Breakeven" sawlog price: the price your mill can pay for a given log and incur neither a profit or a loss.
2. "Defined profit" sawlog price: the price your mill can pay for a given log to gain a profit of X percent.
3. Overrun/underrun percentages for the mill's range of log species, grades, and size classes.
4. Lumber recovery factor: the volume of lumber recovered per cubic volume of logs processed. This is a TRUE measure of mill efficiency (versus overrun or underrun).
5. Lumber grade yield for each of your mill's log grades.
6. Profit per log and per thousand board feet (Mbf) for your mill's log grades.
7. Sawing times per log and per Mbf.
8. Conversion costs per log and per Mbf.
9. Insight into the accuracy and composition of mill log grades.
10. Insight into the buying characteristics of log buyers and/or log producers.
11. Insight into volume and grade yield from specific species or regions.

Thus, the CMS shows profit (or loss) levels for each:

- Species processed.
- Log grade within a species group.
- Log diameter and log length within a species group.

Once the CMS is initiated and the necessary minimum amount of information is gathered, the most common application is to determine a "best mix" of species, grades, diameter, and/or length of logs to be processed to maximize profitability.

Mill study information is useful beyond defining profit and loss levels for specific logs, buying regions, log producer variations, and the like. Data analysis also can lead to more informed decision making in the following areas:

- Changes in the labor force and/or shift schedules.
- Machine center utilization rates, e.g., resaw or edger efficiency.
- Capital equipment investments particularly for saw maintenance and saw purchases.

[1]Palmer, A.J.; Wiedenbeck, J.K.; Mayer, R.W. Cost of Sawing Timber (COST) module. In preparation.

- Training and communications opportunities for loggers and sawmill supervisors and employees.
- Comparisons of mill efficiency with that of similar mills.
- Rate of residue generation per cubic volume of logs processed.
- Data on lumber thickness variation that provide:
  - o Insight on saw performance.
  - o Guaranteed lumber measurements.
  - o Tightening of green-lumber target sizes.
  - o Accurate troubleshooting based on size characteristics.
  - o Enhanced tool for export marketing (defined standard deviation from desired target lumber size).

Protocol and Practices

Commitment

It is extremely important that all sawmill employees, including wage-rate laborers and management, are aware of the details of a proposed continuous mill study. Commitment is essential to success. Employee commitment logically follows when everyone understands and agrees that a mill study will help the company and its employees. The following suggestions may assist in informing and educating mill personnel.

Select a Point Person

It is assumed that sawmill management already is committed to using CMS. Such commitment is necessary and will be keenly sensed by employees. An upper level person should express his/ her optimistic enthusiasm for the CMS system to all employees and may serve as the mill study Point Person or appoint someone to this key role. The Point Person and the CMS initiative should be presented to the sawmill team by an upper level manager with other leaders present to express their support. This effectively conveys to employees that the CMS is important, beneficial to all, and is endorsed unconditionally at all levels of the organization.

The Point Person has ultimate responsibility for the CMS program. He/she must be an effective communicator and able to organize, orchestrate, and observe people. He/she must be self-motivated and detail oriented. The mill study Point Person often is the mill manager or quality control manager, but need not be. The Point Person must have a good knowledge of mill operations and someone who can earn the respect of the entire sawmill team. For example, a highly regarded head sawyer, maintenance professional, or green lumber grader can serve as Point Person in lieu of the mill manager. The Point Person also must be able to solicit, obtain, and maintain the cooperation of mill, log yard, and lumber grading personnel.

Occasionally, large sawmills may hire an outside person to act as their Point Person. While professionals specializing in mill studies are available for long-term contracts, it usually is most effective when the mill study is institutionalized, that is, an "in-house team effort" endorsed by employees and operated without changes in daily sawmill activities. When the program becomes a part of everyday business, it is much less likely to fail.

Technology Transfer and Employee Acceptance

The first charge of the Point Person (hopefully in concert with one or more upper level managers and/or owners) is communication as mill employees might perceive CMS as a test of personal productivity, interpersonal relationships, work ethic, safety, personnel utilization, etc. In all meetings, both formal and informal, the Point Person must emphasize that neither employee efficiency nor performance is being evaluated. He/she must stress that to the extent possible, employees should carry out their duties as usual so that the study measurements reflect normal operations.

Since employee understanding and buy-in are crucial in ensuring the success of the CMS, the introductory meeting must be informative and interactive. There should be adequate time for questions and answers given should be thorough. Continued solicitation of employee suggestions, concerns, and observations should be solicited as the study progresses.

In small mills (15 or fewer employees), a joint meeting with all employees is recommended. In this way, all employees receive the same message and hear the same peer questions and concerns. For large sawmills, it may be effective to conduct a joint employee meeting that is followed by separate meetings with specific employee groups. Each of these group meetings will focus on particular mill study activities and outputs most relevant to the employee group. The following is a listing of suggested employee groups along with topics that might be discussed within each group:

Management and Clerical

- Additional mill study duties (e.g., data entry for study).
- Anticipated mill study costs.
- Anticipated processing impacts such as an initial increase in downtime or other initial slowdowns due to installation of mill study procedures.
- Other data collection activities on log inputs, machine production rates, profit margins, etc. that can be conducted as part of the CMS.
- The importance of accurate and updated operational costs in calculating profits.

Procurement

- The goal is for logs to be identified as to origin, logger, buyer, assigned grade/cost, etc., and the mill's log grading system likely will evolve to better reflect the logs' true mill value.
- Potential development of more accurate log grading and buying systems.
- Potential of tracking logs using barcode tags or similar (if log bar coding is not already in place).
- The Log Price Matrix concept whereby every log of each species, grade, diameter, and length would be assigned a suggested value.
- The use of hand-held PC's to hold suggested log/stumpage pricing data and calculate log/stumpage values based on log/timber buyer inputs.
- Mill study output as a learning tool to enable enhanced log/stumpage grading and purchasing.

Log Yard

- The critical importance of accurately and consistently grading all test logs and the fact that not all test logs may be used.
- The importance of scaling accuracy.
- Who will be the "primary log grader" for study logs.
- Segregation and staging of test logs.
- Cooperation of log loader operator in locating specific test logs as they enter the log yard, or in his/her regular activities in moving logs.
- Rationale for why specific logs may be selected for study.

Sawmill

- Mill study format, including employee physical positions, test log identification marks, data gathering, mill study employee back-ups, importance of maintaining normal mill flow, safety, cooperation, and importance of accuracy.
- Cooperation of the green-chain crew (or drop sort operators) in monitoring for "lost" test boards that may not have been recorded.
- Encourage employees to observe data collection and offer suggestions to increase the study's efficiency and accuracy.

Sawmill Study Basics

There are six essential steps in conducting a successful sawmill recovery study (see Appendix A):

1. Log sample selection is conducted in such a way that information is gathered to fill existing knowledge (data) gaps or to address a specific resource question.
2. Logs are scaled and graded consistently so that comparison of study results is meaningful.
3. Logs are marked distinctively before they enter the sawmill so that they can be identified as they are sawn at the mill's major break-down centers.
4. A method is established for tracking which boards were sawn from which study log or batch of study logs. This method typically requires marking individual boards.
5. The size (surface area and thickness) and grade of each board must to be tallied along with the identification mark that associates the board with a particular log in the sample.
6. Log and lumber data are entered into the computer program in a timely fashion (before it gets lost) and comparative analyses are run and interpreted on a regular basis.

These six steps yield data that allow for comparisons of lumber grade and volume recovery for different types of logs. However, additional procedures are required for comparisons of value recovery (profitability), evaluations of breakeven log cost, analyses of processing efficiency, and assessments of sawing accuracy. These may include:

1. Detailed analyses of manufacturing costs along with log-processing time studies conducted at the headsaw and/or resaw.
2. Surveys of machine center utilization.
3. Measurements of variation in lumber thickness.

A detailed analysis of operating cost requires collecting and summarizing information on the full spectrum of lumber manufacturing costs. Appendix C contains the *Sawmill Business Cost Survey* worksheet that can be used to collect the cost information needed to derive the sawmill's operating cost per minute. That value is entered into the SOLVE program (Wiedenbeck and Dwyer 2000) and similar programs for estimating profitability and breakeven log costs. The cost survey also is available as a computer program (COST)[1] for those who prefer to enter these numbers into the computer and have the program calculate the cost per minute. See Appendix A for more information on log-processing time studies.

Variation in lumber thickness is recognized by everyone as a factor affecting recovery and lumber quality. Lumber thickness traditionally has been measured during sawmill recovery studies conducted by state and federal forestry assistance providers. Although variation in lumber size can be affected by log species, grade, and size, a larger component of thickness variation is associated with the maintenance and condition of the sawing equipment. Therefore, it is not necessary for this study to be coupled with lumber recovery/log value studies. However, as is the case for recovery studies, it is necessary to conduct these studies on a continuing basis. Many information sources are available to help companies initiate an efficient lumber-size control program (Brown 1982; Cassens et al. 1994; Young et al. 2002).

Measuring Downtime

Downtime (lost production) must be recognized in a CMS and its source must be noted so that usual and customary downtime is tallied but abnormal downtime events are not. Downtimes associated with mill cutting schedule changeovers, blade changes, occasional machinery outages, shutdowns caused by bottlenecks related to machine capacity, and lag times when employees are not at their work stations are considered normal. We all know what normal downtime is… after all, it occurs regularly and is the scourge of any astute mill manager. It usually is a focal point for process improvement efforts. Should normal downtime occur during the timing of a test log, it must be recorded. If the test log is somehow the cause of the downtime, the time will be included in the sawing time for that log. This would result in increased processing costs for that test log. If the downtime is not specifically caused by the log that is currently being sawn, it should be recorded, but then subtracted from the log's sawing time. After several hours of headrig timing data have been collected, this non-log-specific downtime can be summed and divided by total headrig time to derive a value for headrig downtime. The cost associated with this downtime is then applied equally to all logs processed. A classic example of customary and usual downtime is time lost due to butt logs with large flares. Such logs may not be stable on the saw's carriage and often cause problems when dropped onto the waste conveyor. This is an example of log-specific downtime that must be associated with the log being sawn and logically would be reflected in slightly increased processing costs for flared butt logs.

Conversely, common sense must prevail should abnormal downtime occur during the timing of a test log. Downtime attributed to the catastrophic failure of a machine component or an electrical outage might logically be overlooked as a "one-time" event that is neither usual nor customary. Sudden and unexpected downtime might be considered abnormal.

Determinations of downtime are best made by the Point Person who will know when downtime reflects a log-specific problem, a normal but non-log-specific problem, or a one-time event. Since the CMS is designed to reflect the mill's ability to process a given log at a defined profit or loss, it is important to recognize, acknowledge, and incorporate log-specific, normal downtime.

When Do You Have Enough Data?

Unless you operate on a static resource and in static markets you never will have so much data that the CMS program can be terminated. When do you have sufficient data with which to run analyses and begin making decisions based on the results? The answer to this question is not a simple one. You have sufficient data when the best-fit regression relationships that are derived by the SOLVE program have an R^2 value that you find satisfactory. The R^2 value is a measure of the strength of the linear relationship between the dependent variable of interest (e.g., lumber yield per log) and the independent variables. In SOLVE, the independent variables modeled in the linear regression equations are scaling diameter and log length by log grade. So for each log grade, several product volume and value outcomes of interest are estimated based on equations that include the log diameter and length variables.

While an R^2 statistic of 0.80 or higher generally indicates a strong relationship between the independent variable(s) and the variable of interest, an R^2 statistic below 0.10 still can be significant. To say that a regression equation is significant is to say that the relationship modeled by the equation significantly improves the prediction of the dependent variable of interest.

So, step one in determining whether you have a sufficient sample size is to conduct a SOLVE run and look at the regression outputs. Your target sample size for this first run should be 40 to 50 logs per log grade. These logs should be well distributed across the range of log diameters and lengths that your sawmill processes. It would be a mistake to study all 8- and 10-foot logs and then use the regression equation based on this sample to estimate log volume and value and profit for 16-foot-long logs. When you run these logs through SOLVE, look at the charts that are part of the regression output. Do you have a good distribution of logs? Are there any extreme results that are not feasible, for example, a ridiculously low lumber yield for a Grade 1 log? If you believe these implausible results are due to tally errors, exclude them from the sample and rerun the SOLVE analysis.

In step two, collect data for another 10 to 20 logs of the same grade, enter this data into the program, and determine how this addition affects the regression relationship. If both the parameter estimates of the equation and the R^2 statistic change substantially by including the additional logs, further sampling probably is needed to determine whether the degree of change remains significant. If little change is noted, you must decide whether you are satisfied with the strength of the relationship, for example, is an R^2 of 0.25 meaningful?

As a guideline, a typical sample size for the traditional 1-day sawmill study is 150 to 200 logs. This sample usually would include logs from three or four log grades, so the average number of logs per grade is about 50. The R^2 for the value and volume prediction equations based on this sample size usually is between 0.20 and 0.60.

Other Considerations

The axiom of crawling before one walks and walking before one runs is appropriate in implementing a CMS. Like any new endeavor, a CMS should begin at a relatively basic level. Ideally, the first CMS data collection effort should take place when the mill is fully staffed and running smoothly. It is assumed that the mill will run only one species—a species that is sawn without difficulty is recommended. For example, basswood and hickory could cause chipper and/or hammer mill (hog) downtime and should be avoided. Similarly, do not use test logs with unusual characteristics such as butt swell, longest lengths, or other anomalies and avoid species that require special green-chain lumber sorts. Although cutting two or more lumber thicknesses may be common in the mill, the first several CMS data collection activities should focus on a single lumber thickness (but allowing for cant production). Cutting a single thickness of thinner lumber (< 6/4) is an excellent way to introduce CMS into the system because this allows mill study personnel to easily manipulate the lumber and thus prevent handling-related backups.

Table 1.—An example of estimated resaw retention times at a feed speed of 150 lineal feet per minute (times are in seconds)

Log diameter (inches)[a]	Log length (ft)				
	8	10	12	14	16
10	26.9	33.3	39.7	46.1	52.5
12	33.7	41.7	49.7	57.7	65.7
14	40.4	50.0	59.6	69.2	78.8
16	40.4	50.0	59.6	69.2	78.8
18	43.8	54.2	64.6	75.0	85.4
20	47.1	58.3	69.5	80.7	91.9
22	50.5	62.5	74.5	86.5	98.5
24	53.9	66.7	79.5	92.3	105.1
26	60.6	75.0	89.4	103.8	118.2
28	67.3	83.3	99.3	115.3	131.3

[a] Small end d.i.b.

Once the learning curve is lessened, more difficult species or multiple lumber thicknesses can be introduced, though multiple thicknesses should be limited to two distinctly different sizes. Nothing is more frustrating to your green chain grader and team than attempting to differentiate 4/4 from 5/4 while also collecting/recording new data to go with the usual grade and surface measure data. Your first introduction of multiple thicknesses into the CMS process should be comprised of 4/4 and 6/4 (or thicker) lumber for easy differentiation. A CMS is no different from any new sawmill activity—a period of adjustment will be required. By clearly communicating the goals, expectations, responsibilities, and outcomes of the CMS from the outset, the learning curve can be dramatically shortened, paving the road to a successful program that quickly becomes part of the normal routine.

Some mill configurations may require collecting supplemental mill data before the first study attempt. If your mill uses a resaw for primary breakdown, a common and recommended preliminary step is estimating the resaw processing time for a given log. Mills of yesteryear relied on the headsaw for primary breakdown, but resaws are typically relied on for primary breakdown today. As a result, it is important to estimate resaw retention time. Modern hardwood sawmill headsaws produce 15 to 30 percent of a mill's gross lumber production; the remaining 70 percent is produced at resaws and gang-saw machines. The SOLVE computer program requires as input the actual time a log is retained on the headsaw. It uses this information to determine the log's processing cost. The processing cost will be more accurate if it is derived from both resaw and headsaw retention times. Logistically, it is difficult to determine a test log's resaw retention time because it is the cumulative time that the resaw band or circle resaw is *embedded in the test log*. A reasonable estimate of resaw processing time can be established by determining the total time the saw is "in wood" for specific logs and then extrapolating those data for other shorter, longer, larger, or smaller logs of the same species and cutting pattern.

Resaw timing tables are only estimates but they can be highly accurate so long as feed rates and operator characteristics remain similar. Resaw timing tables should be constructed for each species included in your CMS. Although similar species will have similar retention times, the range of retention times varies appreciably over the entire range of species. An example of a resaw timing table is shown in Table 1.

Resaw timing also can be expressed as a graph that shows resaw retention times for a range of lengths and diameters. Figure 1 shows resaw retention (saw in wood) times based on data from Table 1.

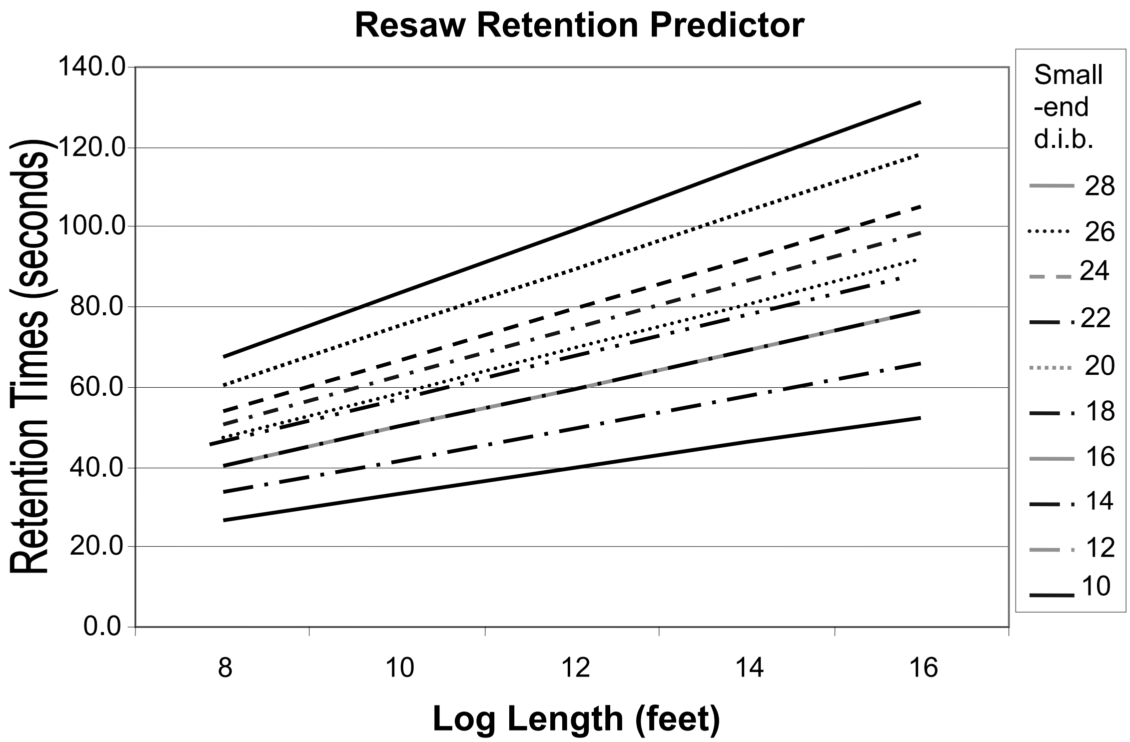


Figure 1.—Plot of resaw retention times for logs of different lengths and diameters based on data in Table 1.

Continuous Mill Study Do's and Don'ts

Case Study 1

Case study 1 concerns a modern hardwood mill producing approximately 18 million board feet (Mmbf) of lumber annually. The mill setup is mostly conventional, with a large band headsaw (13 gauge), a band resaw (15 gauge), two edgers, a trim saw, and a manual green chain allowing 64 sorts. Grading of green lumber occurs at a station located at the head of the green chain. The mill is staffed with an excellent pool of machine operators who understand and recognize the merit and potential of the CMS. As with most other hardwood mills, employee turnover is an issue but has been limited primarily to green-chain and other support employees. The average tenure of machine operators is about 9 years.

Mill management is well versed in several types of mill studies. Batch studies are conducted occasionally but are not commonplace. Statistical Process Control (SPC) charts have been prepared based on green- and kiln-dried lumber-sizing data and have been used both as a sales tool and in determining machinery anomalies. SPC data were not gathered in real time nor presented to machine operators in real time.

Although all logs were bar code tagged and included all applicable log data, questions often arose concerning the validity of log-producer grades, company log-buyer grades, log yard assigned grades, and the ability to predict cutting profitability. "Hunches" related to cutting profitability and loss levels have ranged from "low grade logs are the problem" to "you can't pay too much for a good log." Fortunately, management agreed it did not know the break-even cost for given logs and agreed to define that cost for the most common species and log dimensions within that species group. This sawmill specialized in a unique product derived from a single species group.

As with many operations, concerns about the mill's profitability generated a sense of urgency to find answers. Accordingly, several additional part-time employees were hired to facilitate CMS implementation. The new employees were given a 1-day training session, including about 2 hours of hands-on training at their individual study stations. The initial attempt to use people from outside the mill was reasonably successful. However, the regular mill employees had closely observed the study process and soon volunteered that they could take on these additional duties without hampering their ability to perform their normal duties. Further, they suggested they could collect more data of greater accuracy. Management was impressed and decided to attempt an internally staffed mill study. The CMS soon evolved further to the point that a single "floater" employee was able to execute the study in concert with peer cooperation.

The CMS continued for nearly 2 years, at which time it was believed that sufficient data were collected with which to begin making critical decisions. The data clearly showed that potential profitability was greatest from "middle of the road" logs purchased at the prevailing price. The data also showed that the price of logs of higher grade and larger dimensions could be increased while still achieving the desired profit level. Conversely, the data showed that low-grade logs of smaller dimensions could not be processed at any profit level and should be avoided.

Matrices showing breakeven values for every species, grade, and size were created and loaded into handheld data collectors used by company log buyers. If competition warranted, prices offered for high-end logs could be increased dramatically. Likewise, if competition for high-end logs was moderate, the prices of midrange logs could be increased substantially. Not wishing to alienate log producers, prices remained competitive for low-end and smaller logs. In short, the data collectors loaded with mill-specific information on log profitability, enabled log buyers to know exactly what they could pay for a given log and allowed them to analyze an entire batch of logs so that they could assign values that would allow them to submit a competitive bid.

Ultimately, the log mix entering the mill consisted of logs capable of earning a profit. Logs that could not be processed profitably yet had to be purchased were merchandised. These "loss" logs generally were sold at a price that was less than their purchase price (including necessary transportation costs) but one that was greater than the potential loss incurred if the logs were processed in the mill. Thus, the mill's "opportunity time" gained by not processing "loss" logs was used to process profitable logs.

This sawmill pursued the CMS until upper management changed, complacency surfaced, dynamic markets pressed on, and existing log data became outdated. The mill resorted to traditional methods of log pricing based solely on peer competition and subsequently became less profitable.

Case Study 2

The following CMS has been only partially successful. Data collection has been sporadic and intermediate results have not yet been fully utilized. However, several people within the company including foresters and the sawmill manager have a keen appreciation of the potential value derived in the form of information on breakeven prices for logs of different species, grades, diameters, and lengths.

This large sawmill processes approximately 25 Mmbf of logs per year. The mill operates two shifts at a production rate of about 145 board feet (bf) per manhour. This is a band mill with laser-based headrig scanning, computerized setworks, a high-production band resaw, gang edger, and optimized edging and trimming. About 60 percent of the lumber manufactured is kiln dried. The primary concern is log procurement as the mill is located in a highly competitive region that includes several other midsize to large sawmills and an oriented strandboard manufacturing facility.

Inspired by a savvy and innovative procurement forester, the sawmill has collected lumber recovery data for specific logs for 2 years. The forester spent evenings and weekends developing a spreadsheet program to analyze the log and lumber data and output breakeven log costs. These breakeven costs are based on average log costs and product values for test logs within distinct species/grade/diameter/length classifications. The major difficulty with this sawmill's study plan is that the number of logs that need to be studied within each of these classifications seems overwhelming. As a result, shift supervisors have been reluctant to emphasize this task when other production, quality, and maintenance issues are pressing. In fact, the number of logs required to obtain good estimates of lumber recovery factor (LRF), overrun, and breakeven log cost is <u>much higher</u> than the number targeted by this mill (three logs per class).

A more feasible approach to this problem is now being pursued. Using regression analysis rather than simple class averages (means), fewer logs per class need to be studied to obtain reasonable estimates of the volume and value of products obtained from logs of different species, qualities, and sizes. Regression analysis is conducted using the SOLVE program. In addition, the CMS has been restructured so that the three species that account for more than 80 percent of the sawmill's log inputs are the current focus of data collection. After satisfactory results have been obtained for these species, additional species will be included in the test program. And when meaningful results become apparent, shift supervisors will be more likely to support an ongoing measurement program.

Another difficulty was a lack of timing data for log processing through the headrig. It is not mandatory but desirable that time studies be conducted on the same logs that were used in the CMS recovery tests. In lieu of this, timing studies need to be conducted on logs of a known grade, scaling diameter, and length within each species. Regression analysis can be used to estimate how headsaw retention time varies by species, grade, diameter, and length. Lacking sufficient timing data, the R^2 statistic will be weak and the operating cost assigned to each log may be erroneous. Since cost assignment is a key component in calculating the breakeven log price, the importance of the timing component of the CMS cannot be overstated.

An important opportunity for improving the study approach is related to the scaling of test logs. This sawmill does not measure the large-end diameter of test logs. Without this measure, the cubic volume of the logs cannot be calculated, therefore the Lumber Recovery Factor (LRF) cannot be calculated. LRF is a more meaningful measure of volume conversion efficiency than is overrun because it is a straightforward ratio: lumber product board footage divided by the cubic footage of the log. Log rule formulas, e.g., Doyle and Scribner Decimal C, are so log-size dependent that every discussion of overrun must be qualified by a description of the distribution of log sizes. This is not the case when discussing and comparing LRF results.

The logistics of data collection has been relatively smooth in this sawmill. Production employees are aware of the study and are facilitating the tracking of logs and products. Because this sawmill has two conveyors running between the headrig and the resaw, the sawyer and resaw operator have more control over log spacing which leads to a smoother running CMS.

Because this CMS has been intermittent, a daily routine has not been established for log tests. Thus, for some of the employees there may be a feeling that extra work is burdening them on days when the tests are run. Now, it seems the managers at this sawmill are recommitted to conducting a regular mill study program with the primary goal of providing critical timber costing data to the company's procurement foresters.

Case Study 3

CMS can and occasionally do fail. Fortunately, failure can be a positive experience if the factors that caused the failure are identified and corrected. Failure is most commonly associated with high-production mills with convoluted processes, including multiple edgers, sash gang saws, automated green-lumber grading stations combined with automated lumber-sorting systems, circuitous remanufacturing routings, and large lumber storage (surge) capacities.

This case is based on several large mills where professionally orchestrated studies were attempted but failed. Production for this composite mill is about 10 to 12 Mmbf per year (per shift) of all common species, grades, and thicknesses. Although a second shift had been utilized in the past, lack of profitability has eliminated the second shift and paradoxically the economies of scale that the second shift afforded. Equipment types and layout are typical: state-of-the-art machine centers, including optimization at the edger and trimsaw. To increase profitability, production rate is so strongly emphasized that excess surge capacity at machine centers disappears and material handling bottlenecks become commonplace. In pursuit of gross production, the mill uses a sash gang saw to process cants into lumber. Essentially, this sawmill resembles many of today's modern, high production hardwood sawmills.

Upper management at this sawmill is acutely aware of markets and market trends and is concerned that profitability has diminished appreciably over the last decade. Turnover in manual labor positions is common among peer mills, which greatly influences the decision to purchase optimized machinery and mechanized/computerized lumber sorting. Fortunately, the mill has a seasoned and able group of machine operators, though these veteran employees have witnessed a "tightening of the belt" and are now performing multiple duties due to a "leaner" mill staff.

Mill management attends professional association meetings and participates in discussions about raw material, manufacturing costs, and general efficiency. Similar to many sophisticated mills, management decides they need to *know* where the mill's profits lie and how to *quantify* profit levels by species, log grade, and size. They also want to know how best to compete at their specific location, how to purchase and assemble an optimal mix of logs with the greatest profit potential, and the best schedule for operating the sawmill. Recognizing its limited staff, management solicits outside help. Through their state's forest products utilization and marketing specialist, they meet with a team of professionals well versed in mill studies. Most of these professionals are employed by governmental agencies that provide assistance to a wide range of forest product industry clients.

The team of sawmill specialists meets with the mill management to determine their needs. The team explains the types of assistance they offer and the protocol required for an intensive mill study. Unlike the CMS discussed previously, the team explains that a 1-day mill study will be attempted that focuses on the combination of species and log grades that management believes affords the most profit potential. This is not a batch study but instead will track each log processed in the day long study. This poses a problem because tracking, marking, and identifying test boards are extremely difficult in this high-production mill. For example, the use of a sash gang saw with 14 internal saw lines results in a 14-fold increase in the marking of test boards. Once problems are experienced in marking the boards produced from one cant, the study begins to spiral out of control as the study team falls behind production.

Even if the study team marked every test board successfully, the members of the team responsible for recording surface measure and grade found it difficult to keep pace. High-production mills often allow large volumes of boards to build in front of the trim saw and/or green lumber grading station. As a result, boards sawn from logs processed during the early part of the study may remain in the system for hours becoming mixed in with boards having higher numbers. This outwardly simple issue can be a confounding one as the person recording lumber outputs must quickly sift through a thick stack of tally cards to find the correct one. Of course, the problems outlined in this study could be eliminated with the CMS approach. Rather than dealing with voluminous data gathered over the course of a day, that same data could be collected with greater accuracy and at a more leisurely pace when mill conditions permit.

The failure of a mill study can be devastating if caused by lack of cooperation within the study team, or worse, a loss of interest or support by management. Lack of interest can result from turnover within management; lack of direction from owners, corporate shareholders or sawmill supervisors; or other volatile and uncontrollable conditions within the mill. A well-orchestrated CMS can lose its energy with the loss of a "champion" such as the mill manager or Point Person. While a "replacement" manager or Point Person may be knowledgeable and willing, he/she usually is on a steep learning curve dealing with numerous mill issues including those that require immediate attention. Once the momentum of a CMS is lost, it can be regained only through a costly process of employee reorientation. Likewise, an existing mill supervisor who is given new direction, goals, or challenges by management might be forced to reduce his/her participation or that of key employees. Finally, factors such as installing and adapting to new machinery configurations, new work shifts, and complicated cutting schedules could compromise or dismantle a CMS. Luckily, the study can be suspended and resumed as conditions permit.

Where Do You Go From Here?

You've finally done it! As part of your CMS you've amassed sufficient data for a given set of logs, accurately calculated your operating cost, and analyzed your log data using the SOLVE computer program. Most users initially scour the output "Breakeven Log Price" and "Defined Profit" tables to identify the species, grades, lengths, and diameters of logs that have the greatest profit potential.

Your study results should generate a host of additional questions and improvement endeavors such as:

- How can I buy more logs with high profit potential?
- How do I buy logs with high profit potential without buying ones I don't want?
- Is my LRF within the realm of efficiency?
- Is my LRF comparable to that indicated by my computerized setworks printouts?
- How do I conduct margin analysis for my current mix of sawlog inputs?
- How do I conduct margin analysis for my ideal mix of sawlog inputs?
- How do I find markets for logs that I cannot process profitably?

As discussed previously, most mill managers use their new information on sawlog costs to assemble a revised log price list. This list should be incorporated into a handheld PC or data collector so that the log yard manager and timber/log buyers <u>know exactly</u> what they can pay for logs of a given species, grade, diameter, and length. Armed with this information, your buyers should be able to compete effectively for the logs you wish to process. Less desirable logs probably can be purchased competitively. Many companies specializing in handheld data collectors for the primary forest products industry offer programs that assist a log/timber buyer in developing a competitive "log package" bid price, while allowing the buyer to emphasize the purchase of the most desirable logs. Of course, it is up to the user of such programs to supply the correct log-cost inputs, which are easily obtained from the SOLVE program.

The CMS combined with SOLVE will not provide absolute answers to the wide array of questions facing most hardwood mill managers. As markets for green and kiln-dried lumber change, so will the outputs from SOLVE. Operating costs also change, as does productivity with respect to volume and grade yields. Thus, the elusive profit target is a moving one. However, by knowing your operating cost, markets, and the price you can pay for your sawlogs, you will be able to compete effectively in the global market.

Literature Cited

Brown, T.D. 1982. **Quality control in lumber manufacturing.** San Francisco: Miller Freeman Publications. 288 p.

Cassens, D.L.; Bankston, J.R.; Friday, J.S. 1994. **Statistical process control of hardwood lumber target sizes: is it time?** Forest Products Journal. 44(1):48-50.

Wiedenbeck, J.; Dwyer, J.. 2000. **Sawmill performance systems for industry: SOLVE 2000.** In: Meyer, D.A., Proceedings of the 28th annual hardwood symposium, West Virginia now—the future for the hardwood industry?, May 11-13, 2000, Davis, WV; National Hardwood Lumber Association, Memphis, TN: 19-29.

Young, T.M.; Bond, B.H.; Wiedenbeck, J. 2002. **Reducing lumber thickness variation using real-time statistical process control.** In: Smalley, B., Proceedings of the 30th annual hardwood symposium, Current topics in the processing and utilization of hardwood lumber, May 30 - June 1, 2002, Fall Creek Falls, TN; National Hardwood Lumber Association, Memphis, TN: 103-112.

Appendix A: Requirements for Continuous Mill Study

Tools and Materials

The following tools and materials are required for a CMS:

1. Tree/log marking paint.
2. Lumber crayons (nonfluorescent), railroad crayon chalk or equivalent.
3. Log rule.
4. Log tape (preferably feet and tenths).
5. Cant hook — full length for log yard use, half length for in-mill use.
6. Mill log-grade rules (or log rules to be used in study).
7. Clipboards.
8. Stopwatches (preferably minutes and tenths).
9. Calipers (if lumber measurements are taken).
10. Forms/tally sheets (provided in appendix).
11. Personal safety equipment (ear/eye protection, hardhat, gloves, etc.).

Personnel and Positions

CMS personnel positions and the number of individuals required per position will differ among sawmills. Mills with circuitous lumber paths, multiple headsaws or resaws, or detailed systems to "remanufacture" or upgrade previously processed boards may require additional manpower and forethought in personnel placement. The following personnel assignments are typical for a hardwood mill with resaw:

- One person to time log retention on headsaw.
- One person to mark numbers on cants and boards generated at the headsaw.
- One or more person(s) to mark numbers on cants and boards at the resaw.
- One person to mark numbers on boards at the infeed (or outfeed) of the edger.
- One person to tally green lumber volume and grades and cant volumes (green-chain grader).

In positioning people at mill study stations, top priority needs to be given to locating a safe position for conducting the study task. This may require the installation of new safety devices. Also, it is critical that safety rules, regulations, and perspectives are communicated and emphasized to employees.

It is possible to reduce manpower by appointing one individual to serve in more than one capacity. Once CMS is established, it may become apparent that data collection could be collected with fewer people. In "real world" applications, detailed CMS have been refined such that only two people collect all data.

Cooperation is of the essence. In virtually all sawmills, careful observation by all employees will result in CMS data collection that is nearly invisible, requires little effort or cost, and yields invaluable information.

Log Sample Scaler/grader

Before a log study can be run, the log sample must be selected, measured, and marked. A sawmill that conducts studies several times per week can select logs randomly by arbitrarily choosing logs from a list of log numbers that have been assigned or by predetermining that the Xth log in the log pile will be a study log and selecting every Yth log after that. Both sampling approaches are easy to implement and unbiased. Over time, a random sample of study logs within each species will be representative of the logs processed by the sawmill.

During the early phases of a CMS it often makes sense to select the log sample in a more deliberate way. To begin to build the log sample data set, logs that are representative of the grades, diameters, and lengths that make up the largest portion of the sawmill's log inputs should be selected. For example, a typical hardwood sawmill will sample more sawlogs with small-end diameters of 12 to 16 inches. Exceptionally small or large-diameter logs will not be considered until several logs in the more typical diameter (and length and grade) classes have been evaluated. Only then should the sawmill select logs of less common sizes and grades for study. After the full spectrum of log inputs has been sampled, logs chosen for subsequent "continuous" studies can be selected in a more random fashion as described in the previous paragraph.

Why continue to conduct studies after a full spectrum of log inputs have been evaluated? Because sawlogs of the same species, grade, diameter, and length are not necessarily of relatively equal value, nor is sawmill processing efficiency static. Analyses of log variation indicate that to obtain reliable results for average overrun, average percentage of No. 1C and Better lumber grade recovery, and average breakeven log purchase price, a minimum of 75 logs must be sampled within a given species, grade, small-end diameter, and log-length class! A smaller sample size usually is adequate when regression analysis will be used to estimate outcomes for different log diameters and lengths within a given log grade.

After the sample has been selected, the logs must be scaled, graded, and marked. Results will be more accurate and reliable if all studies are conducted using the same methods and personnel. It is especially important that the same log scaler/grader is used in every study and that this person is responsible for scaling/grading most of the sawmill's log supply during normal operations. If it is not possible for the same scaler/grader to perform this task on a regular basis, every effort should be made to ensure that the second scaler/grader is equally familiar with the company's log grades and has worked with the primary scaler/grader (so that he/she does not introduce gross variation into the study). Grading and scaling of the log should include specific information on species when multiple species are processed together (e.g., when sawing "red oak" logs many sawmills include black, scarlet, northern, and other oak species). Also, both the average small-end and large-end diameters (inside the bark) must be recorded along with nominal and actual log length (actual length can be measured in feet and tenths or in feet and twelfths). Finally, volume deductions associated with log sweep, crook, and decay must be noted and log grade must be determined carefully, i.e., the grader should look at all four log faces before assigning a grade.

After each sample log is selected, scaled, and graded, it must be marked so that it can be readily distinguished from other logs. The best method for doing this when five or fewer logs are to be studied during the sawmill shift is to spray paint both ends of each study log a different color as soon as the log has been scaled and graded. The color can then be noted on the log tally sheet alongside the log grade and scale information. If many logs are being tested on the same day, numbers must be spray painted on the log ends. Use a color that stands out the most on the species being tested. For example, yellow, orange, and white paint are good choices for red oak, cherry, and walnut but poor choices for yellow-poplar, birch, and white oak. When spray painting numbers on the logs, be sure to distinguish between 6 and 9 by underlining these numbers on the log ends. If the study includes dozens of logs, the scaler/grader must be aware of other numbers that could be misinterpreted when the log rolls and likewise, underline them (e.g., 18 and 81, 16 and 91, and 19 and 61). If the numbers painted on the logs are not easily distinguished in the log yard, they will not be detected in the sawmill.

Headsaw Timer

Measuring the length of time required to process study logs through the headsaw is required if the sawmill manager wants breakeven log-cost information for different log classes. Without this data, volume, product value, and recovery efficiency measures can be obtained—overrun, lumber recovery factor, No. 1C and Better lumber grade yield, lumber value per Mbf—but the most critical information, profitability, will be lost.

The person timing the headsaw should be positioned so that he/she clearly sees the leading end of the log and can observe the entire sawing process. Ideally, the person also has a good view of the entire sawmill. Seeing the end of the log is important so that the tracking number or color can be identified correctly. Seeing the entire sawing process is necessary to obtain accurate timing information and viewing the sawing process allows the timer to describe events that affect the sawing rate (e.g., when the sawyer takes a false pass or has difficulty loading the log on the carriage). Being able to observe the rest of the sawmill is useful since the person timing the headsaw also will attempt to capture information on other causes of downtime for the headsaw (e.g., the transfer conveyer to the resaw is full or broken). Since this person not only will be using one or more stopwatches but also writing, his/her position should be such that there is a horizontal surface upon which a clipboard can be rested. The person timing the headsaw must be positioned in a safe location and equipped with ear protection and safety glasses.

There are many methods for timing the headsaw. For a simple CMS in which only a few logs are studied each day, these logs can be separated from each other by one or more non-study logs. In this case, the person timing the headsaw can obtain the necessary information with a single stopwatch so long as it has at least one intermittent timer (i.e., capability to record the length of an intermittent event while the total sawing time for the study log continues to accrue). If the study logs are processed continuously (not separated by non-study logs), the timer will need two stopwatches with intermittent timing capability or a stopwatch with multiple memory functions.

The basic information that needs to be captured when timing the headrig is the length of time required to process each study log through the headrig. This information is used to determine the approximate processing cost for each study log. This cost is arrived at by multiplying the sawmill's total operating cost per minute by the number of minutes (and fractions thereof) required to process the log through the headsaw.

Capturing the length of time required to process a log through the headrig is not always as straightforward as it might seem. If there is downtime during the sawing of a study log, the timer must decide whether the downtime is associated with the sawing of the test log or if it instead was caused by another problem not associated with the specific log being sawn. For example, if the sawyer stops sawing a test log because the edger is down and the edger infeed chains are at capacity, that downtime clearly is not associated with the study log. By timing and recording the length of this stoppage, the headrig timer can later subtract this time from total processing time recorded for the log to derive a fair estimate of the required sawing time. However, if downtime occurs due to problems associated with loading the test log onto the carriage, turning the test log, making a false pass, or taking an extra slab while sawing the test log, the time should be recorded on the downtime tally <u>but not subtracted</u> from the total log-sawing time. This information can be used to identify and solve problems before they become unmanageable.

When timing the headsaw to obtain data on log processing rates that can then be used in estimating log processing costs, only the total processing time for each study log is needed. There are several "trigger points" that can be used to start the timing. The best approach is to begin timing the sawing of a log the moment the carriage returns to the log-loading position after having cleared itself of the previous log. Thus, the time associated with loading the log onto the carriage is incorporated into the timing. While this activity usually is quick and smooth, it can occasionally be slow and cumbersome due to log size, form, and grade characteristics. Larger logs, those with crook or sweep, excessive butt swell, or a prominent defect, may not load smoothly onto the carriage. In the past, some people have begun the headrig timing cycle when the log first touched the carriage or the knees, or when it was first dogged on the carriage. However, if these timing triggers are used, you will not capture data on how quickly different logs are transferred from the log infeed deck to the carriage.

Once the timing begins, it is stopped only if there is downtime on the headrig that <u>is not</u> associated with the log being sawn. As soon as the headrig resumes operation, the stopwatch is restarted. If equipped with two stopwatches or one with memory functions, it may be desirable to time and record the length and causes of the downtime periods. Since a CMS requires that headrig timings be conducted regularly over an extended period, downtime information obtained as an extra element of the headrig timing can aid in identifying the sources of sawmill inefficiencies. What length of time should be documented as downtime? People experienced in timing the operation of the headrig can record downtime periods as short as several seconds. However, every downtime period that is captured on the stopwatch must be written down along with the cause. A rule of thumb for timing the headsaw is to measure, record, and describe downtime periods that are 10 seconds or longer.

Some sawmill managers will be interested in obtaining more detailed information on headrig processing rates beyond the basic measure of how many seconds are required to process each log. For example, when using multiple stopwatches and/or watches with memory functions and dual timing capabilities, it is possible to capture not only total sawing time and downtime but also information on the length of time associated with loading the log on the carriage, turning and slabbing the log, and cutting productive and unproductive (e.g., false passes) sawlines.

Finally, while timing the headrig is mandatory, if a sawmill study is to yield information on breakeven log prices and profitability, it is not mandatory that the logs used in the lumber recovery study be the same logs that are timed at the headrig. Since the study logs are marked, measured, and graded, it is convenient to measure headrig processing time on them. However, if the data on log grade, scaling diameter, and length are readily available for other logs or sets of logs, a larger data set of log-timing information can be obtained by timing the headrig independently of the recovery study. Since there often is high variability in the time required to saw logs of a given species, grade, and size, it is important that many logs be studied to obtain reliable estimates of average sawing times.

Sawn-Product Markers

Once the sawmill study has begun, the most crucial tasks are those of the board/cant markers positioned at the headrig, resaw, edger, gangsaw, etc. These members of the study team must ensure that every piece of lumber, flitch, or cant that exits each machine is marked as obviously as possible with the correct tracking number or color. If this job is not executed correctly, products will be lost in the system or mistakenly associated with the wrong study log. To obtain usable recovery data, all products sawn from each study log must be tracked through the system until their final values have been determined (a function of grade and volume). To obtain log-specific recovery information, you must be able to match each board/cant with the original study log from which it originated.

When study logs are distinguished by colors painted on log ends, the sawn-product markers will mark the boards with crayons that match the various colors. When study logs are distinguished by numbers, the same numbers must be written legibly on the lumber and cants as they are produced at each sawing center. Writing <u>legibly</u> can be difficult when the boards are passing by the marker at speeds of 200 to 400 lineal feet per minute. If the number being written has more than one digit (i.e., ≥10), the task is even more challenging.

Marks must be located on the lumber and cants such that subsequent sawing operations will not remove or obscure the marks. For example, a marker located along the outfeed conveyor of the headsaw will mark a waney-edged board (i.e., flitch) midway across its width so that the mark is not removed in the edging process. Yet, the mark cannot be placed too close to the ends of the boards where it might be removed at the trim saw. An attempt should be made to place two marks on a board whenever possible (e.g., write the board's number 1 foot from both its leading and trailing end as it passes by or write the number on both faces of the board). This provides added insurance that the board will be correctly tallied.

Should a marker be confronted with a log whose number cannot be distinguished or should the marker fail to mark a board/cant, this should be noted. Depending on the speed at which the study is being run, this may not be possible. When the number or color cannot be distinguished, markers should decipher or interpret the mark as best they can and include a question mark in the number when it is written on the boards that are sawn from the log/cant in question. For example, if the first digit of a number is clearly a 3 but the second digit cannot be distinguished, the marker should write 3<u>?</u> on the board. Or if the second number looks like a 5 but there is doubt, the marker should write 3<u>5</u>?, underlining the digit in question.

In the case where the marker falls behind or fails to write a mark/number on a board, noting information on the missed piece on a pad of paper might prove helpful. Information to be recorded should include the time, tracking number or color of the piece that was missed, and its estimated size. This information may be sufficient to enable the sawmill study coordinator to make a good estimate of the missing piece's volume and value. Alternatively, the study coordinator may decide that the log needs to be culled from the study so that the missing product data does not result in inaccurate log-recovery results.

Board and Cant Tally Person

To obtain essential data for calculating lumber recovery volume, overrun, No. 1 Common and Better grade-yield percentage, the value of products recovered, and the profit associated with processing different logs, you need to tally the products produced from each log or each group of logs. The method used needs to be accurate and must be compatible with the grading and sorting/stacking system at the mill. An accurate method is one that can account for the grade and size (e.g., surface measure, cant thickness) of all products sawn from the test logs. Thus, the tally must be conducted after the board has been graded.

The tally station should be safe, have adequate lighting, and be spacious enough that boards can be flipped (to check for colors or numbers designating a test piece that might be hidden on the bottom face of the board) and briefly evaluated. In some situations the lumber grader may be able to record the test piece tally. More often, the tally person works alongside the grader and tallies the surface measure, cant size, and grade of the product as it is assigned by the grader. The tally can be conducted at a distance with the tally person looking back through stacks of test boards and cants that have been sorted by the green chain's lumber handlers.

In implementing a CMS, the question of how many logs can be tracked and tallied accurately should be considered carefully. If the study design calls for only four logs per shift per day, different colors (rather than numbers) can be used to distinguish the logs and the lumber grader could tally the grades and sizes of the products on a special tally sheet. This is more likely to be feasible if the lumber-grading operation runs at a moderate pace and the grading station is at least 25 feet long. If test logs are processed individually during the shift (i.e., the wood from one log is totally out of the system before the next log enters the sawmill), a grader-based tally system of the products derived from the logs is even more feasible. Alternatively, the grader may recruit someone off the green chain to help record the test tally. In either case, someone should alert the grader to the fact that the test pieces are approaching (the study coordinator or the trimsaw operator) and easy-to-use tally sheets should be prepared ahead of time and located within easy reach of the grader. For a study in which colored paint and crayons are used to distinguish the logs, a tally sheet might look like Table 2.

The tally process can be easier in sawmills that stack lumber on the green chain in distinct grade and length packages. If these sawmills run smaller studies with logs distinguished by colors rather than numbers, a person stationed on the backside of the trim saw can re-mark the colors written on the board faces onto the ends of the lumber and cants. These marks should be detectable within the stacks of lumber assembled on the green chain (unless the lumber packages have uneven ends such that some of the ends are obscured by overhanging pieces). The tally process can then be conducted at a more leisurely pace by surveying the packages after all products have been sawn from the test log(s). This tally system has a reduced risk of tally errors <u>except that everyone must work to ensure that no packages containing test pieces are removed from the green chain until the tally has been conducted</u>.

If a larger set of study logs is being examined so that numbers are used to distinguish the logs and cants from each other for purposes of tracking the products that come from each, the tally sheet at the grading station would look like Table 3.

The sawmill study team also must be aware that many sawmills reroute boards back into the sawmill for remanufacturing when the grader determines there is an opportunity for the board to be upgraded. When this is a marked study board, there is a risk that it could be double tallied. This problem can be eliminated if the tally person knows which marks the grader puts on boards that are to be remanufactured (marks that signal to the lumber handlers on the green chain that the board is to be remanufactured), and avoids tallying the boards during their first pass through the grading station. After the boards are edged or trimmed to a different size and grade, they pass back through the grading station again. It is this product information that must be tallied.

Table 2.—Example of sawmill study product tally sheet used to record the grade and size of lumber products produced from test logs when a limited number of colors are used to mark the logs

	BLUE						RED					
SM	**FAS**	**F1F**	**1C**	**2C**	**3A**	**4x6**	**FAS**	**F1F**	**1C**	**2C**	**3A**	**4x6**
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
Other												
Sum SM												
SM	**WHITE**						**GREEN**					
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
Other												
Sum SM												

Table 3.—Example of basic tally sheet used to record the grade and size of lumber products produced from test logs when numbers are used to distinguish between logs

Number on board/cant	Surface measure/ cant size	Grade	Number on board/cant	Surface measure/ cant size	Grade
: :	: :	: :	: :	: :	: :

In some sawmills the cants produced are diverted to a stacking line separate from the lumber green chain. In other mills, multiple cant sizes are produced and the grader may not be required to grade and measure them as they pass through the grading station. In these situations it may be necessary to assign someone to track and tally the cants.

Other Types of CMS

The Two-Person Study Team

A CMS can be refined so that only one or two persons collect log and product data. In larger mills, a common position is that of "floater." The floater generally has knowledge of numerous processes and machines and can assume various mill positions required. The two-person team is most effective in a larger mill that utilizes a resaw and has adequate surge capacity on the resaw incoming cant deck. In such mills, the cants sawn from the test logs can be stored while the headsaw timing and flitch/board marking is taking place. The two-man team relies on the cooperation of other machine operators. The study team's size should not be reduced until the test procedure is virtually second nature to all mill personnel.

While each mill is different and will require a unique mill study plan, a typical two man data collection scenario follows:

- It is assumed the study log has been measured, scaled, graded, and ends marked. It is important to mark test logs and boards clearly. The use of bright paint for log ends and railroad crayons or black carbon markers reduces the chance of losing a board and facilitates the tasks of the green-chain grader and tally person(s).
- The green-chain lumber grader is alerted to the imminent arrival of test boards. It is assumed that the study lumber will be scaled, graded, and recorded by this person.
- The test log enters the mill and timing begins when the empty carriage is in position to load the test log.
- Test Person 1 is positioned to time the headsaw and mark jacket boards and perhaps second interior headsaw boards.
- Test Person 2 can assist by marking the reverse side of headsaw test boards and/or marking the other end of test boards. This person usually is positioned safely at the infeed board deck at the primary edger. Where there are multiple edgers, cooperation from the person manning the edger infeed board decks is mandatory so that test boards are routed to the designated edger. The edger operator(s) must cooperate and mark test boards that will be ripped into two boards; the new boards must be marked clearly.
- When the headsaw releases the test-log cant, Test Person 1 finishes timing the headsaw and proceeds to the incoming cant deck on the resaw. Where possible, all four faces on both ends of the test cant(s) are marked clearly. Otherwise, as many sides of the cant as can be accessed are marked. Marks are made at least 1 foot above the end of the cant to reduce the chance of losing test boards at the trim saw. It is assumed a manual override is available on the incoming resaw cant deck. By positioning the test cant with space on each side of the cant, Test Person 1 can access all four faces (the bottom face usually hangs over the chain conveyor so it can be marked from the bottom). In other words, cants are not stacked tightly until the test cant has been fully marked.
- Because the ends of the test-log cants are marked clearly, Test Person 1 can easily identify the test cant as it circulates on the resaw's merry-go-round. He/she is positioned safely at the resaw table, enabling him/her to mark each newly exposed face of the test cant each time a board is removed. Test Person 2 can assist at the resaw so that <u>both</u> ends of the newly exposed test cant face can be marked after each saw pass. Or, Test Person 2 can remain at the edger and re-mark test boards as necessary. If the mill study is truly a team effort, it often is possible to mark only one end (and one face) of each test board, eliminating the need for Test Person 2. This is feasible only if the sawmill team has developed an effective communication system using eye contact and hand signals.

- If the sawmill operates a gang resaw (or bull edger), board marking is a greater challenge. The saw's operator must stop the outfeed belt to allow time for multiple boards to be marked. When a gang saw is in use, writing numbers (corresponding with log numbers) can be problematic. Instead, using multiple colors of markers, each color corresponding with a different test log, is a more feasible approach.
- The trimmer operator must cooperate and mark any test board that will be crosscut into two shorter boards. Both of these new boards must be marked.
- Test Person 2 can assist the green lumber grader or tally person. These employees usually can perform their normal duties and collect test-board data so long as the tally forms for the test logs are available and the number of test logs is limited. Cooperating mill personnel often assist by positioning marked boards face up so that the green-lumber grader can easily recognize them. Voice-activated recorders can be helpful but usually require that the information be transcribed at a later date. This can make the CMS more complicated and expensive. Dictation directly to a computer combined with visual character recognition usually results in an unacceptable error level due to extraneous background noise. Soliciting improvement from the green-lumber grader or tally person usually results in a workable solution for gathering data while normal duties are performed. In lieu of tallying at the green chain or drop-sorter grading table, all test-log lumber could be sorted into a single stack and redistributed after tallying. This option rarely is feasible in high-production mills, mills with many sorts, mills with limited green-chain stacking capacity, or those that frequently remove sorted lumber stacks.
- Test Person 1 probably is the best candidate for verifying the test data (checking to make sure that it seems reasonable) and entering it into the SOLVE analysis program, as he/she usually is personally involved and clearly remembers log idiosyncrasies, downtime limitations, and other extraneous factors that can influence results.

The Off-Species Approach

A log testing method that is less likely to produce "lost identity" tally errors is the off-species approach. Test logs are run individually over the course of the shift (e.g., five logs over 8 hours) with these logs being a different species than is being processed in the sawmill that day. Choosing the species to be processed after the next species changeover will facilitate lumber sorting. However, the species chosen must be easily distinguished from the one that is currently being processed in the mill. For example, on a day when red oak logs are being processed, choose yellow-poplar or hard maple rather than white oak for the test.

This type of test is remarkably simple. It begins with the log grader/scaler marking the ends of the day's test logs with numbers (e.g., 1 through 5). When a test log reaches the debarker operator, he/she notes the number. At the end of the shift, the debarker operator will have listed the order in which all test logs entered the sawmill. No other marks need to be placed on the logs, cants, or lumber during processing. Timing the log's residency time at the headrig is the only special study task that needs to be conducted. When the lumber approaches the grader, he/she writes the tally on a unique tally sheet, indicating "Test Log 1" on the tally. At the end of the shift, the debarker operator's test log order-of-entry list can be matched with the headrig timings and grader tallies.

The First Five Logs Approach

Another variation of the log study approach is the first-five logs method, which has been used for several months by a sawmill in Vermont (Paul Frederick, Vermont Department of Forests, Parks & Recreation, 2004, pers. commun.). On the evening prior to startup, five logs are scaled, graded, tallied, and marked. They are placed on the infeed conveyor, passed through the debarker, and positioned so that they will be the first five logs sawn in the morning. Everyone in the mill knows to expect these logs so the likelihood that logs or lumber will be "lost" during the study is minimized. The green chain, edger, and trimsaw infeed conveyors were cleared at the end of the previous shift, so these boards move through the system quickly and directly. Because relatively few logs are being tracked, different colors of spray paint can be used on the logs and lumber. Thus, the difficult task of writing and later interpreting the numbers written on each board can be avoided. This method is particularly effective if the logs are run as a single batch. However, for batch processing to be meaningful in determining recoveries and breakeven costs for different types of logs, all of the logs in a batch should be of the same grade, scaling diameter, and length.

Timing the logs on the headrig or resaw with the first-five-logs methods is effective and capturing the processing time of each log (time needed to assign an operating cost to each log) is relatively easy. However, it does not provide a true downtime because the sawmill system is not fully loaded with logs/cants/lumber so delays associated with full-handling bottlenecks are not evident at shift startup.

Appendix B: SOLVE 2003 Log and Lumber Data Tables

Table 4.—Required format for log data file used to input log data into SOLVE-2003 (LogDefect represents board footage volume deduction associated with cull, log crook, etc.; SawingTime is entered in minutes and tenths of minutes)

LogNum	LogGrade	SmallEndDia	LargeEndDia	LogLength	Inches	LogDefect	SawingTime	SawingSeq
1.00	4.00	10.00	11.00	10.40	0.00	0.00	2.24	1.00
2.00	2.00	11.00	12.00	12.50	0.00	0.00	2.10	2.00
3.00	3.00	10.00	12.00	10.50	0.00	7.00	1.91	3.00
4.00	3.00	10.00	12.00	12.40	0.00	0.00	2.01	4.00
5.00	2.00	14.00	18.00	12.70	0.00	0.00	3.42	5.00
6.00	3.00	9.00	11.00	12.10	0.00	0.00	2.01	6.00
7.00	4.00	14.00	17.00	10.60	0.00	28.00	3.70	7.00
8.00	2.00	14.00	16.00	10.30	0.00	0.00	2.63	8.00
9.00	2.00	10.00	13.00	12.70	0.00	0.00	2.42	9.00
10.00	2.00	12.00	18.00	14.60	0.00	0.00	3.02	10.00

Table 5.—Required format for lumber data file (named lumber_d.xls) used to input lumber data into SOLVE-2003 (Thickness is entered as quarter-inch board thickness; each board's surface measure is entered under Surface)

LogNumber	LumberGrade	Thickness	Surface	MultiThicknessNo
1.00	4.00	5.00	7.00	0.00
1.00	5.00	5.00	4.00	0.00
1.00	6.00	5.00	7.00	0.00
1.00	7.00	5.00	4.00	0.00
1.00	8.00	4.00	14.00	0.00
2.00	3.00	5.00	7.00	0.00
2.00	4.00	5.00	14.66	0.00
2.00	5.00	5.00	6.00	0.00
2.00	7.00	5.00	4.00	0.00
2.00	8.00	4.00	16.00	0.00

Appendix C: Sawmill Business Cost Survey

SAWMILL*:**________________________________DATE*:**_________________________

INVESTMENT Land.................. $______________@_______ years depreciation

Mill Building.................... $______________@_______ years depreciation

Mill Equipment.................. $______________@_______ years depreciation

Rolling Stock.................... $______________@_______ years depreciation

Other............................ $______________@_______ years depreciation

Average Log Inventory..............______________ mbf or $ _______________

Average Timber Inventory...........______________ mbf or $ _______________

Average Lumber Inventory..........______________ mbf or $ _______________

LABOR Note on wages: Not all companies employ all positions. Make certain to account for multiple personnel in any given position description. Timber Buyers and associated costs of buying stumpage, cut logs, logging crews, logging rolling stock, etc. should be incorporated into log cost versus listing as direct mill employees. Mill Log Yard employees, log yard costs, machinery, etc. should be incorporated in direct mill costs. Kiln employees and KD lumber graders should not be included in mill labor figures. Apportion wages if employee serves multiple profit centers or serves dual roles.

Are Workers Compensation costs included in wages shown below? Yes ☐ No ☐

Are Social Security (FICA) costs included in wages shown below? Yes ☐ No ☐

Are Unemployment Compensation costs included in wages shown below? Yes ☐ No ☐

Mill Manager.. $____________/hour

Mill Foreman(s).. $____________/hour

Plant Manager... $____________/hour

Head Sawyer(s)... $____________/hour

ReSawyer(s).. $____________/hour

Cant Station Operator... $____________/hour

Debarker Operator.. $____________/hour

Maintenance Men... $____________/hour

Edger Men... $____________/hour

Trimmer Operator... $____________/hour

Green Chain Men... $____________/hour

Off Bearer... $____________/hour

Filers.. $____________/hour

Green Lumber Graders... $____________/hour

Forklift & Rolling Stock Operators............................ $____________/hour

Secretarial .... $____________/hour

Quality Control.. $____________/hour

Floater(s)... $____________/hour

Log Yard Manager... $____________/hour

Log Yard employee(s)………………….………………… $___________/hour
Lumber Sorter employees.……………………………….. $___________/hour
Other…….……..………………………………………. $___________/hour

If FICA, Worker's Comp, Unemployment Comp, are not included in preceding hourly employee wages, please provide below. State cost per unit time, example $15,000 per 6 month, or $2500 per month, or $30,000 per year:

Worker's Compensation: ***Total Cost = $_____________per ________***
FICA Social Security: Total Cost = $_____________per ________
Unemployment Compensation: Total Cost = $_____________per ________
Medicare: Total Cost = $_____________per ________

TAXES
Property Taxes……………………………………..... $_____________per year
Use Taxes…………………………………………... $_____________per year
Fuel / Highway Taxes……………………………….. $_____________per year
Inventory Taxes……………………………………... $_____________per year
Other…………………………………….………… $_____________per year

INSURANCE
Fire………………………………………….………… $_____________per year
Liability…………………………………...……... $_____________per year
Health……………………………………………….$_____________per year
Life…………………………………………………. $_____________per year
Corporate……………………………………………$_____________per year
Other…………………………………….………… $_____________per year

REPAIRS AND MAINTENANCE
Equipment……………………….……………… $_____________per year
Buildings..…………………………….………… $_____________per year
Contract Services…..……………………….. $_____________per year
Grounds………………………….…………… $_____________per year
Other………………….…………….………… $_____________per year

UTILITIES ETC.
Electricity……………….…………….………… $_____________per year
Diesel……………..………….……………….. $_____________per year
Gasoline………….………………….………….. $_____________per year
Natural and/or LP Gas……….…………….. $_____________per year
Phone……………….…….….……………….. $_____________per year
Internet………………….….…………………$_____________per year
Other…………………….…….……………… $_____________per year

ADMINISTRATIVE
Postage……………….…….………………… $_____________per year
Office Supplies……….……….…………… $_____________per year
Dues & Subscriptions…………….………... $_____________per year

	Professional Services……………………….	$______________	per year
	Discounts allowed…………….……………..…	$______________	per year
	Advertising……………………….…………	$______________	per year
	Depreciation……………………….………	$______________	per year
	Training…………………….…..…………	$______________	per year
	Meetings…………………………….………	$______________	per year
	Legal Fees………………………..………	$______________	per year
	Accounting Fees……………………….……	$______________	per year
	Dividends.……………………….………	$______________	per year
	Bonuses……………………………….……	$______________	per year
	Other……………………………….………	$______________	per year
MISCELLANEOUS	Notes Payable / Loans / Repayments…….....	$______________	per year
	Interest ………………………………..…	$______________	per year
	Bad Debts……...…………………….…..	$______________	per year
	Consulting Fees……..…………………..…	$______________	per year
	Fees, Permits & Licenses……………..…..	$______________	per year
	Automobile Expenses…………….……...	$______________	per year
	Recruiting…………………………..……	$______________	per year
	Company Activities……………………...	$______________	per year
	Computers & Supplies……………………..	$______________	per year
	Lease & Rent……………………….……	$______________	per year
	Penalties…………………………….……	$______________	per year
	Credit Card Fees..……………………..…	$______________	per year
	Warehouse Fees……………………….…	$______________	per year
	Custom Trucking (excluding log hauling)…..	$______________	per year
	Charitable Contributions…………….……..	$______________	per year
	Travel & Entertainment……………………	$______________	per year
	Other…………………………….………	$______________	per year

Additional Mill Study Cost Information

Average Work Schedule Per Shift 1: _____________am until __________________pm

Lunch Break Schedule Per Shift 1 : _____________minutes. Company paid? Yes ☐ No ☐

Employee Breaks Per Shift 1: _________# breaks per shift. ________minutes per break

Average Work Schedule Per Shift 2: _____________pm until __________________am / pm

Lunch Break Schedule Per Shift 2: _____________minutes. Company paid? Yes ☐ No ☐

Employee Breaks Per Shift 1: _________# breaks per shift. ________minutes per break

Average Downtime per Shift: Shift 1_________minutes Shift 2________minutes

Did you include employee breaks in Downtime minute figure? Yes ☐ No ☐

Number of paid Holidays per Year: _____________

Do you have a "Shut Down Week(s)?" Yes ☐ No ☐ Number of Shut Down Days/Year: ______

Average Daily Log Consumption: ____________ mbf logs Log Rule: _____________

Average Daily Lumber Production: ____________ mbf lumber (including cants)

Annual Lumber Production: ____________ mbf lumber (including cants)

Do the preceding lumber production figures include ALL cants, outs, shims, blocking etc? Yes ☐ ***No*** ☐

Average Daily or Annual Chip Production: __________tons or cubic yards (please circle)

Chip Price FOB your mill: $________per ton/cubic yard (please circle)

Average Daily or Annual Bark Production: _________tons or cubic yards (please circle)

Bark Price FOB your mill: $________per ton or cubic yard (please circle)

Average Daily or Annual Sawdust Production: _________tons or cubic yards (please circle)

Sawdust Price FOB your mill: $_________per ton or cubic yard (please circle)

Average Log Yard Inventory: ____________board feet Log rule:______________

Average Green Lumber Inventory: ____________board feet

Log Inventory maintained by: _____ pencil & paper

(Check one) _____ bar code tags

_____ batch system

_____ good educated guesses

Log Procurement Cost Information

Timber Buyers and all associated costs of buying stumpage and/or cut logs should be incorporated into log cost versus listing as a direct mill cost. Likewise, all costs associated with harvesting standing timber, such as logging crews, skidders, forwarders, chain saws, logging rolling stock, etc., also should be incorporated into log costs. The purpose of this worksheet is to determine the actual cost of log procurement for your mill. Total procurement cost will ultimately be incorporated into log cost.

Approximately what percentage of your total annual log purchase is derived from?

Standing Timber purchases……………………………………..…. _________%

Cut log purchases from

Log Concentration Yard(s) ……………………………….……….. _________%

Woods-side purchases………………………………..………. _________%

Gate Log purchases (at mill) ……………………………….…..……. _________%

Other (*example: Company owned lands, landowner Cooperatives*) …..…….. _________%

Gate logs are defined as cut logs delivered by an independent log producer to your log yard(s) or your satellite log yard(s). Do you pay a premium for gate logs? Yes ☐ No ☐

If yes, what is the approximate percentage increase paid for gate logs…….________%

Or, what is the approximate increase in price paid for gate logs…….$________per bd.ft.

If you buy cut logs woods-side or from concentration yards, is the cost of log transportation to your main log yard or satellite concentration yard burdened by the log producer? In other words, is your cut log pricing based *F.O.B. your log yard(s)?* Yes ☐ No ☐

How many full time timber (log) buyers do you employ?………………….……..__________buyers

Total annual salary / wages ***for all buyers***?…………..…………… $_________per year

(*including prorating of employees buying logs on part-time basis*)

Total per diem, including food & motel, for all buyers? ………..... $________per year

Entertainment costs ***for all buyers***? ..……………….………….. $________per year

Total bonuses paid to ***all buyers***? ………………………………. $________per year

Other overhead costs of ***all buyers***?

Phone: …………………………………………………..… $________per year

Remote Offices & staff: ………………………………. $________per year

Travel & Entertainment: ………………………………. $________per year

Paint, Log Tags, Tools, computers, etc. …………………. $________per year

If FICA, Worker's Comp., and Unemployment Comp. are not included in preceding hourly or annual log buyer's wages or salary, please provide below. State cost per unit time (example $15,000 per 6 month, or $2,500 per month, or $30,000 per year):

Worker's Compensation: Total Cost = $____________ per ________

FICA Social Security: Total Cost = $____________ per ________

Unemployment Compensation: Total Cost = $____________ per ________

Medicare: Total Cost = $____________ per ________

Does your Company provide vehicles for your buyers? Yes ☐ # Vehicles: ________, No ☐

If Yes, Approximate Initial Vehicle Cost or Annual Lease……………… $________per vehicle

Average Length of Ownership? ……………………………… $________years

Vehicle then sold on open market? Yes ☐ No ☐

Or, Vehicle retained for in-Company use? Yes ☐ No ☐

Annual Operating Costs for ALL buyer vehicles ……………………… $__________/year

(*Includes fuel, maintenance, tires, insurance, licenses, tolls, etc.*)

If transportation is not provided, do you reimburse transportation costs to all buyers? Yes ☐ No ☐

Reimbursement rate……………………………………$_________per mile

Average annual total miles driven by ALL buyers………. _________miles

Do you employ or utilize timber spotters or others who do not directly work for your company?

How are these individuals generally paid?

On a commission basis? Yes ☐ No ☐ If Yes, at what percentage…_______%

A flat fee basis? Yes ☐ No ☐ If Yes, at $_____ per event or per year. (circle one)

Other? Explain?

Do you operate any satellite log concentration yards? Yes ☐ No ☐

If Yes, how many satellite yards? _________yards

Approximate TOTAL annual cost of all satellite yards…………………… $__________/year

(*includes office, staff, rolling stock, utilities, land rent, etc.*)

Some mills re-sell (merchandize) logs that cannot be economically utilized by the mill. Examples include resale of veneer grade logs, pallet logs, undesirable species, reject (firewood) logs, etc.

Approximate total volume of all merchandized logs?……… _________bf/year

Approximate total value of all merchandized logs? …………$________/year

Profit (loss) from log merchandizing?……………………… $________/year

Number of Company owned logging crews?……………………….. ________crews

If the Company buys standing timber but does not have its own logging crews and associated logging equipment, do you employ contract logging crews? Yes □ No □

Average price per thousand board feet paid to contract loggers? ….. $________/mbf

Does this custom logging cost include transportation to your logyard(s)? Yes □ No □

If contract log hauling is used, approximately what cost is incurred?

Is contract hauler paid:

One way? Yes □ No □

Semi Trailer?……………… $___________per mile or per mbf? (circle one)

Straight Truck?…………….. $___________per mile or per mbf? (circle one)

Straight Truck with Pup?…... $___________per mile or per mbf? (circle one)

Both ways? Yes □ No □

Semi Trailer?……………… $___________per mile or per mbf? (circle one)

Straight Truck?…………….. $___________per mile or per mbf? (circle one)

Straight Truck with Pup?…... $___________per mile or per mbf? (circle one)

Approximately how many board feet:

Per semi-load?…………………………..…….. _______bd ft.

Per straight truck load? …..……………..…….. _______bd ft

Per straight truck + pup trailer load? ....…….. _______bd ft

Appendix D: Requirements and Expectations for a Successful Noncontinuous Sawmill Study

Benefits of a Sawmill Study

1. Sawmill recovery studies yield information about your mill's performance that can help you make more informed decisions when considering:
   - ♦ Log procurement prices.
   - ♦ Changes in the labor force and shift schedules.
   - ♦ Capital equipment investments, particularly for saw maintenance and saw purchases.
   - ♦ Training and communications opportunities for loggers, sawmill managers, and non-supervisory employees.
2. You can compare many of your results with those from dozens of other sawmill studies conducted since 1990 to determine your mill's efficiency relative to other mills.
3. After you and your employees learn how to conduct these studies, you can begin implementing regular, smaller-scale studies. Regular self-checks and lumber recovery and cost analyses will make you a much more effective decision-maker and help your supervisors and employees gain a continuous improvement perspective.
4. You can use this study to elicit the advice of sawmill specialists on changes that might yield mill improvements.

Key Information Generated in Study

1. Breakeven sawlog prices for the log sizes and grades usually processed.
2. Overrun/underrun percentages for a range of log grade and size classes.
3. LRF — the volume of lumber recovered compared to the cubic volume of logs processed. This is a true measure of efficiency.
4. Lumber grade yield for your log grades.
5. Information on lumber thickness (sawing accuracy) for lumber sawn at your major saws, e.g., headsaw and resaw.

Focus Areas for Meeting Specific Needs

If you have questions that you have been struggling with or need supporting data for a capital investment decision, consider a sawmill study that is tailored to meet your specific needs. Examples of the kinds of specific assessments that could be incorporated into a study include:

1. Resaw utilization rates.
2. Recovery rates for logs harvested by contract loggers versus those purchased as gatewood.
3. Productivity and recovery rates for logs of different lengths.
4. Recovery rates for a particularly important log-diameter class.
5. Lumber grade recovery when sawing with your headrig or edger optimizer utilized fully versus partially.
6. Lumber grade recovery for logs purchased at a particular location.
7. Lumber thickness variation before and after saw changes.
8. Residue generation rates per cubic volume of logs processed.

What to Expect During the Study

Sawmill efficiency studies typically are conducted on only one species or species group per study, e.g., red oaks. The species should be one that is particularly important to you.

- ♦ The study typically takes 2 to 3 days to complete: 1 day to prepare the log sample, 1 day to run, and sometimes an additional day to grade the lumber produced during the study.
- ♦ During day 1, three to five people will select, measure, and grade logs and paint numbers on them. <u>Your most experienced log grader will be needed for the study</u>. Study leaders will spend time in your mill observing material flow and planning the details of the next day's study.
- ♦ During day 2, 8 to 12 people will assemble about 1 hour before the study begins (usually at the beginning of the shift) and then enter the mill to learn about their jobs for the day. *Typical study jobs include: a) headsaw timer; b) two people to mark numbers on cants generated at the headsaw;*

c) one person to mark numbers on boards from the headsaw; d) one person to mark numbers on jacket boards at the infeed to the edger; e) one person to re-mark numbers on boards at the outfeed of the edger; f) one or two people to measure the thickness of boards; g) one person to tally the number and sizes of cants produced from each log; h) one person to roam the log yard and mill as an assistant, coordinator, and observer; i) one person to tally the lumber-grade assigned by your grader (if the pace at the grading station is slow enough to keep up with); j) two to four people to mark cants and boards at the resaw for mills with a resaw operation.

♦ During day 3, two to three people usually are needed to work with your grader to handle, grade, and tally the lumber generated during the study. Also, one or two additional people will make final observations, acquire any missing operational data from management, and document initial feedback on the mill's operations. An exit interview with key mill personnel concludes the on-site study.

What is Required of You to Ensure a Successful Study

1. A breakdown of total sawmill costs, including information on capital depreciation expenses, labor rates and schedules, overhead expenses, downtime rates, etc. Currently, this information is gathered by completing a three-page worksheet. Once the worksheet is completed, we can help you derive an accurate estimate of your mill's operating cost per minute. Alternatively, if you know your operating cost per minute, you need provide only that figure. Data on cost per minute is required if we are to provide you with the most important study result: breakeven log costs by log grade and size. This information should be given to your state contact at least 2 weeks before the scheduled study dates.
2. Several weeks before the study, let us know of any issues or concerns affecting your mill so that we can tailor the study to your needs.
3. Consider whether your company has any insurance and liability issues associated with having non-company personnel (e.g., state and/or federal sawmill study team members) participate in the study. If there are such issues, address and resolve them well ahead of the day of the study.
4. Because we do not want your employees to feel overwhelmed and hassled, it is important that you hold a meeting before we arrive to let them know both the purpose and nature of the study. They should be reminded to carry out their duties as normally as possible. In the meeting, stress that the study will not be analyzing their personal efficiency or performance.
5. Help on the log yard on Day 1. We will need help from your loader operator in obtaining logs from your inventory piles that fit the study sample, as well as an open area where we can lay out 100 to 300 logs side-by-side. At some point, we will need your most experienced log grader / buyer for 2 to 3 hours to assign your company's log grades to the sample logs.
6. Access to the mill on Day 1. Study team members who will coordinate the study (two to four) will need time to observe mill operations so that the logistics of the next day's study can be finalized.
7. The study team will need the most current data on log costs and lumber prices for the species and sizes that will be cut during the study on Day 2.
8. An afternoon meeting with key sawmill management team members on Day 1. We might have questions or concerns after observing the mill's layout and material flow and organizing the log sample. A meeting to discuss the Day 2 logistics will ensure a safe, smooth-flowing, and successful mill study.
9. Good communication and coordination with and assistance from sawmill personnel are needed on Day 2. It is important that the log loader operator, sawyer, grader, and all sawmill team members understand what we are doing so they can help us keep everything coordinated during the study.
10. A commitment to provide sufficient personnel with which to accurately grade the lumber either

online during Day 2, or at an offline location (your principal lumber grader plus a forklift operator) on Day 3. It is nearly always the case that the offline grading is required to ensure accuracy of the tally. Sawmill studies usually fail at the grading station because the boards pass so fast that the tallier cannot hear the grader's surface measure and grade call, read the number on the board, and record the data without making mistakes.

11. On Day 3, attendance by key managers at an exit conference that typically is 45 minutes to 2 hours long. At this time, sawmill team leaders share important observations, summarize results from early data analysis, clarify with you your key information needs and questions, and announce the timetable for delivery of full results. You also will be asked to share your ideas for improving study procedures.

Post-Study Followup

About 2 weeks after the sawmill study is conducted, you will receive two reports and an implementation plan from the sawmill study team as well as a follow-up call and visit from your state forestry contact. The follow-up communications will include:

1. The results of the lumber size analysis (thickness) study will be mailed to you and to your state forestry contacts along with a letter that interprets the lumber size variations recorded at your mill. Your state forestry contact will schedule a meeting to discuss the results. This meeting should be held no later than a month after the study dates.
2. The results of the processing recovery and efficiency (sawmill) study will be mailed to you and your state forestry contact(s) about 3 weeks after the study. This report includes comprehensive results and a summary report that highlights key outcomes. You also will receive a letter that synthesizes the observations/comments of sawmill specialists who participated in the study. Your state forestry contact will schedule another meeting to discuss the results.
3. A short information sheet will be mailed to you along with an implementation plan for conducting regular studies at your sawmill using your own personnel and resources.
4. Please inform your state forestry contact(s) of changes you make in log procurement or sawmill operations as a result of knowledge gained by participating in this study. Also, please inform your contacts of any topics that were not addressed in the report, or of ideas you might have on changing the study process to better meet your needs.

Using the Study Results

Always bear in mind that these study results represent only a snapshot of your mill's performance when a single species is processed on a single day. You should note whether mill operations were typical on the day of the study. Use these notes to further interpret the study results. If you make procurement or operational changes as a result of the study, we strongly recommend that you reevaluate processing efficiency after the changes are enacted.

Data on lumber recovery and size from studies conducted since 1990 are being combined so that updated benchmarks on sawmill performance for important hardwood species will be available. We can provide information on overrun/grade yield/recovery for species other than that run during the mill study.

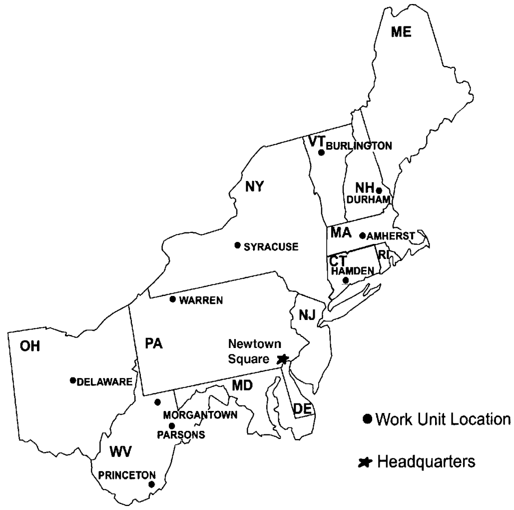
Additional information on collecting data to aid in future decision-making can be obtained from your state forestry contact or the USDA Forest Service. Your primary Forest Service contacts are:

- Northeastern Research Station, Princeton, WV (304-431-2700 or http://www.fs.fed.us/ne/princeton/index.shtml).
- Forest Products Laboratory, Technology Marketing Unit, Madison, WI (608-231-9504 or http://www.fpl.fs.fed.us/tmu/index.html).
- Northeastern Area, State and Private Forestry, St. Paul, MN (612-649-5246 or http://www.na.fs.fed.us/spfo/fp/index.htm), and Durham, NH (603-868-7689).

Mayer, Robert; Wiedenbeck, Jan. 2005. **Continuous sawmill studies: protocols, practices, and profits**. Gen. Tech. Rep. NE-334. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 32 p.

In today's global economy, the "opportunity cost" associated with suboptimal utilization of raw material and mill resources is significant. As a result, understanding the profit potential associated with different types of logs is critically important for sawmill survival. The conventional sawmill study typically has been conducted on a substantially similar "batch" of logs to gain insight into gross (volume) yield, grade yield, and profitability of those logs. Traditional mill studies capture data only for a day or two. Mill study data should be collected continuously so that the results reflect potential profitability for a range of operating conditions.

Keywords: hardwood, logs, breakeven, optimization, recovery



Headquarters of the Northeastern Research Station is in Newtown Square, Pennsylvania. Field laboratories are maintained at:

Amherst, Massachusetts, in cooperation with the University of Massachusetts

Burlington, Vermont, in cooperation with the University of Vermont

Delaware, Ohio

Durham, New Hampshire, in cooperation with the University of New Hampshire

Hamden, Connecticut, in cooperation with Yale University

Morgantown, West Virginia, in cooperation with West Virginia University

Parsons, West Virginia

Princeton, West Virginia

Syracuse, New York, in cooperation with the State University of New York, College of Environmental Sciences and Forestry at Syracuse University

Warren, Pennsylvania

"Caring for the Land and Serving People Through Research"