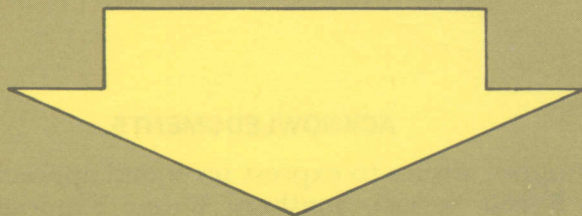



**SAWMILL
IMPROVEMENT
EFFICIENCY
ANALYSIS**



ALABAMA AGRICULTURAL EXPERIMENT STATION
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Information contained herein is available to all persons without regard to race, color, sex, or national origin.

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Sawmill Improvement Efficiency Analysis

Honorio F. Carino¹

INTRODUCTION

MANY sawmills in the United States operate below peak potential efficiency and unnecessarily lose money. This is the conclusion drawn from hundreds of sawmill improvement studies (7,8) conducted by the USDA Forest Service under the Sawmill Improvement Program (SIP). This public service program has been in existence since 1973. Under this program, teams of sawmill specialists, usually from the USDA Forest Service and State Forestry Commission, conduct on-site mill studies based on a request for assistance from the sawmill owner who is interested in participating in the program.

A typical SIP study consists of measuring the sizes (diameter and length) of about 100 sound, straight logs and processing these as a batch at the mill in the normal manner. Lumber from these logs is carefully tallied. Measurements of thickness variation are taken on 100 boards per size class and 20 measurements for width variation are taken per size class. Along with this information, headsaw kerf, resaw kerf, planing allowance, minimum lumber trim allowance, and shortest lumber saved are all fed to a computer² for analysis. The computer printout returned to the mill operator contains information about the following:

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²The original SIP computer program, which was written in FORTRAN 77 language, runs on a Sperry-Univac computer. As a part of the programming effort in this research project, a version of this program was installed by the author in the IBM 3033 computer system at Auburn University. The size (about 15,000 lines) of the program is available upon request from the author.

1. Current level of mill conversion efficiency (measured in terms of the lumber recovery factor (LRF), i.e., the ratio of the board feet of lumber output to cubic feet of log input),
2. Potential increase in lumber recovery by improving log bucking practices,
3. Potential increase in lumber recovery by reducing green lumber target sizes, and
4. Potential increase in lumber recovery by going to computer control of the sawing process.

Significant improvements in sawmill conversion efficiency have been reported by users of the SIP (3,6,7,8). But it is not known whether such improvements actually enhanced the profitability of individual participating mills because SIP studies focused on the technical aspects of sawmill conversion efficiency. These studies have helped identify opportunities for sawmill operators to increase lumber recovery (7). However, the impact on profits of changes in sawing systems and/or operations has not been assessed within.

Theoretically, LRF improvements should lead to either reduced log volume input for the same lumber production level or increased lumber output for the same amount of log input. Logically, either case should yield additional profits for the mill. This is not always true, however, particularly in the second case where mill design and layout can restrict production. For example, volume productivity at the headsaw may be expected to increase by 10 percent due to improvement in the sawing process, but it may not be realized if a processing station downstream (e.g., the edger or trimmer) is already operating at capacity.

An analysis of material flow and equipment capacity utilization should be considered when trying to determine attainable conversion efficiency. The economic desirability of implementing any process and/or facility design changes necessary for achieving potential improvements in conversion efficiency should also be evaluated. Sawmill owners should not accept changes proposed by improvement studies unless they result in increased profits.

From a sawmill owner's standpoint, maximizing profit is a more central goal than maximizing product volume yield, according to current SIP efficiency criteria. An enhanced SIP analysis is needed which includes the systematic evaluation of potential improvements in sawmill conversion efficiency within

the framework of profit maximization. A more detailed discussion of such an approach is presented in this publication.

METHODOLOGY

Basic Approach

Figure 1 illustrates the probable profitability situation faced by a sawmill before and after an improvement study. That is, either it is currently making profit (A_0), losing money (B_0), or just breaking even (C_0). For proprietary reasons, however, it may be impossible for an outside analyst (e.g., SIP analyst) to know definitely which situation applies to the study mill. Under the traditional SIP approach, current profitability seems to be irrelevant as far as the efficiency improvement analysis is concerned. It is assumed that an improvement in conversion efficiency will result in an increase in mill profit as symbolically represented by the asterisk at the tip of the arrows emanating from A_0 , B_0 , C_0 . In contrast, the new approach to sawmill improvement analysis can be described as follows:

Through linear programming (LP) analysis (5), an attempt is made first to allocate the scarce resources of the mill to maximize its profitability under current conditions, thus to improve mill profitability to the level indicated by either A_1 , B_1 , or C_1 , figure 1. At the same time, potential improvements

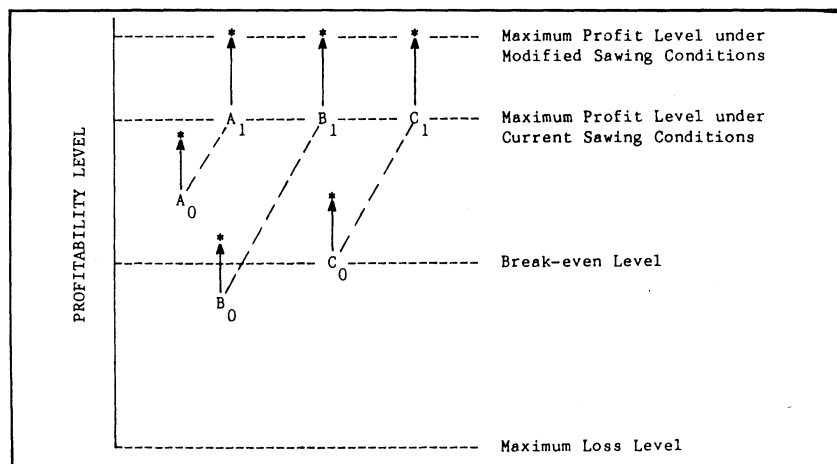


FIG. 1. Hypothetical mill profitability situations. The letters (A, B, and C) with 0 subscripts designate the probable before-improvement profitability status of the mill, while those with 1 subscripts designate the profitability status of the mill after scarce resources have been optimally allocated. The asterisks designate the profitability level attainable by the mill through standard SIP conversion efficiency improvement methods.

in conversion efficiency without changing the sawing system are also determined. Then, as in the traditional SIP approach, further enhancements to conversion efficiency obtained by changing the sawing system are identified. Finally, the expected incremental economic benefits resulting from such changes will be assessed. Consequently, under modified sawing conditions, the profitability of the mill can be further improved from the A_1 , B_1 , or C_1 situation, figure 1.

Linear Programming Analysis

As a first step, linear programming should be used to establish appropriate benchmarks for the efficiency analysis. Such an analysis can also determine potential improvements in conversion efficiency under current mill conditions without changing the sawing system. This is possible because LP analysis can indicate which log size classes are unprofitable or less profitable to process and show efficiency gains from excluding them from the input stream. In most cases, smaller log size classes fall in these categories. Their elimination will result in improved conversion efficiency since it has been well established that lumber recovery improves with increases in log diameter and quality (10).

LP analysis can also indicate which operation or workstation inhibits higher productivity. This information is needed to determine the limits to improving conversion efficiency under the current mill setup. It also serves as a basis for making equipment changes in order to attain the maximum potential improvement in lumber recovery and throughput.

A generalized linear programming model for optimizing the allocation of resources in a southern pine dimension mill was developed. A complete formulation of the model may be obtained by writing the author at 108 M. White Smith Hall, Auburn University, AL 36849. The objective of the model was to maximize profits subject to an extensive list of constraints that describe mill and market conditions.

Input data required for the LP analysis include the following: diameter and length measurements from 300 to 500 randomly selected input logs, processing time for each size class of log input at various machines, productive machine time (or up-time), log costs, product prices, product yields per log input, and grade and size distribution of lumber output.

Regression analysis can be used to estimate the technical coefficients (i.e., processing rates) needed for the LP model.

The processing rates can be calculated from processing time data which should be collected using about 100 random observations at each machine center considered in the analysis.

Regression analysis has also been used to predict product yields from each type of log input (2,9). The nature of the products (i.e., predominantly two thickness classes) produced in a typical southern pine dimension mill may permit estimating product yields without resorting to extensive data collection. This can be accomplished by simulating the sawing of logs using the BOF (Best-Opening-Face) computer program (4) developed at the Forest Products Laboratory in Madison, Wisconsin. However, since the product yield estimates provided by the BOF program are based on ideal log and sawing conditions, these are expected to be considerably higher than those actually obtained in practice. Consequently, the net revenue estimates obtained in the LP analysis will have to be considered as upper-bound or maximum values. This should not prove to be critical to the evaluation of incremental economic benefits, however. Besides, the results of such studies are really intended to serve as guideposts, which should complement management's experience and judgement in making operating policy decisions.

The LP model is generalized in the sense that the analyst or user can specify unique mill setups and/or operating scenarios. This is made possible by the data entry and matrix generator computer programs assembled by the author. The input generator was written in FORTRAN 77 to interface with a Job Control Language program for executing a linear programming run in a computer system (such as the IBM 3033 mainframe computer at Auburn University) with a SAS/OR (Statistical Analysis Systems/Operations Research) compiler released by the Statistical Analysis Systems Institute, Inc., Cary, North Carolina.

It should be noted that the LP model represents a southern pine dimension mill in which the choice of log raw material input is not limited to conventional sawlogs. Logs that are normally sold in round form as poles, peelers, and pulpwood can also be considered as input in the production of finished and/or rough dimension lumber and by-products such as chips and sawdusts. Net revenue is the objective function to maximize subject to the limitations imposed by available log supply, lumber volume yield per log input, machine capacity, and

product sales forecast. In many instances, the appropriate model for a given mill may be a reduced version of the more general model presented. Through the input generator, the analyst has the flexibility to model a very wide range of situations involving southern pine dimension mill systems.

Conversion Efficiency Analysis

There are many ways of improving sawmill conversion efficiency (7,10). However, the following actions are considered most practical:

1. Excluding unprofitable or less profitable log size classes from the headrig input
2. Eliminating unnecessary log overlength (i.e., the excess of the sum of the nominal log length plus the minimum log trim requirement)
3. Reducing the green target size on the lumber

LP analysis can provide the necessary information or basis for pursuing the first action. The last two actions are based on the output of the SIP computer program, which is used for evaluating both current and attainable levels of lumber recovery. The capacity limitations of the various machines in the mill system should be considered in evaluating the attainable level of conversion efficiency.

SIP standard procedures (1) are followed in collecting the data needed for conversion efficiency analysis. These data include diameter and length measurements and actual lumber tally from 100 to 300 sample logs, thickness variation measurements from 100 boards per size class, width variation measurements from 20 boards per size class, sawkerf measurements, log-breakdown or sawing method, planing allowance, minimum lumber trim allowance, minimum size of lumber saved, and final desired condition of lumber.

Incremental Economic Analysis

In general, the incremental benefit from conversion efficiency improvement can be calculated as the difference between the before-improvement and the expected after-improvement revenues.

The incremental benefit resulting from excluding unprofitable or less profitable size classes of logs from the headrig input can be calculated directly from the linear programming output. Two production options are considered in calculating the incremental benefits from the elimination of unnecessary

log overlength and the reduction of the green lumber target size to a level which conforms with industry norms. The first option (Option 1) refers to increased lumber production given the same log input, and the second (Option 2) refers to reduced log input given the same level of lumber production.

Under Option 1, evaluation of the expected incremental benefit from eliminating log overlength is based on the assumption that excess wood from log overlength will be chipped. It is also assumed that if proper bucking of long or tree-length logs is employed, current overlength material can be turned into lumber by including it in the next sawlog segment to be cut. Therefore, the incremental benefit is the difference between the potential net value of the lumber and the current net value of chips recovered from overlength materials. This relationship can be defined by the equation:

$$J = V \times (L - G)$$

where: J = incremental net revenue expected from the elimination of log overlength under production Option 1, \$/hour

V = volume of log overlength, cunits (or 100 cubic feet)

$$= I \times (P/100)$$

I = volume of sawlog input (without overlength) from LP analysis, cunits

P = percent improvement in LRF due to the elimination of log overlength as indicated by SIP analysis

L = average net revenue from lumber per unit volume of log input as indicated by LP analysis, \$/cunit

G = net revenue from green chips, \$/cunit

However, if the elimination of log overlength means reduced log input as in Option 2, the incremental savings would be the difference between the cost of log overlength material and the net value of chips currently produced from the same material. More specifically,

$$Q = V \times (S - C)$$

where: Q = incremental savings expected from the elimination of log overlength under production

Option 2, \$/hour

V = volume of log overlength as calculated above, cunits

S = average sawlog cost, \$/cunit

C = unit price of green chips, \$/cunit

Under Option 1, the incremental benefit from the reduction of the green target size on the lumber is the difference between the net value of additional lumber recovered and the net reduction in chip revenue. This relationship is mathematically expressed as

$$K = R \times [W - (0.833 \times C)]$$

where: K = incremental net revenue expected from the reduction of green target size on the lumber under production Option 1, \$/hour

R = volume of additional lumber recovered, MBF (or 1,000 board feet)

$$W = 0.10 \times [(FM - FC) \times I \times (1 + P/100)]$$

FM = LRF under modified mill conditions with log overlength, board feet/cubic feet

FC = LRF under current mill conditions with log overlength, board feet/cubic feet

I = volume of sawlog input (without overlength) from LP analysis, cunits

P = percent improvement in LRF due to the elimination of log overlength as indicated by SIP analysis

W = average lumber price (\$/MBF), weighted by the distribution of lumber output as indicated by optimal LP solution

C = unit price of green chips, \$/cunit

The incremental savings from the reduction of green lumber target size under production Option 2 can be calculated using the following relationship:

$$T = E \times S$$

where: T = incremental savings expected from the reduction of target size on the lumber under production Option 2, \$/hour

E = reduction in log input required to produce a given lumber output, cunits

$$S = I \times (1 + P/100) \times (1 - FC/FM)$$

FM = LRF under modified mill conditions
with log overlength, board feet/cubic
feet

FC = LRF under current mill conditions
with log overlength, board feet/cu-
bic feet

I = volume of sawlog input (without
overlength) from LP analysis, cunits

P = percent improvement in LRF due to
the elimination of log overlength as
indicated by SIP analysis

S = average sawlog cost, \$/cunit

A CASE STUDY

An actual sawmill study was conducted in 1984 mainly to test the empirical applicability of the foregoing approach to sawmill conversion efficiency improvement analysis. The case study mill has a rated production output of 120-130 MBF of lumber per 8-hour shift. Figure 2 shows the simplified mill and machinery layout. The equipment includes a single cut-off saw, a ring debarker, a circular headrig, a two-saw scragg, a double-arbor circular gangsaw, a four-saw edger, a chipping edger, and a Canadian trimmer. The mill also has a whole-log chipper, a planer mill, and two dry kilns.

At the time of the study, the mill's log supply consisted of long or tree-length southern yellow pine logs with minimum top diameters of about 6 inches. Logs were bucked to size, including a minimum trim allowance of 1.0 inch, using a single circular cut-off saw. A cumulative probability distribution of the bucked sawlog input based on volume as well as piece count is given in figure 3. Sawlogs with small-end diameter of up to 12 inches (i.e., approximately 80 percent of throughput) were processed through the scragg saw. Those with small-end diameters larger than 12 inches were sawn at the main circular headrig. Basically, the mill was employing the cant method of sawing, i.e., logs were initially sawn into cants at the scrag saw or circular headrig, and the cants were subsequently sawn into boards and lumber at the double arbor circular gangsaw.

The mill was producing lumber in the 5/4-inch and 8/4-inch nominal thickness classes, which were sold dressed and

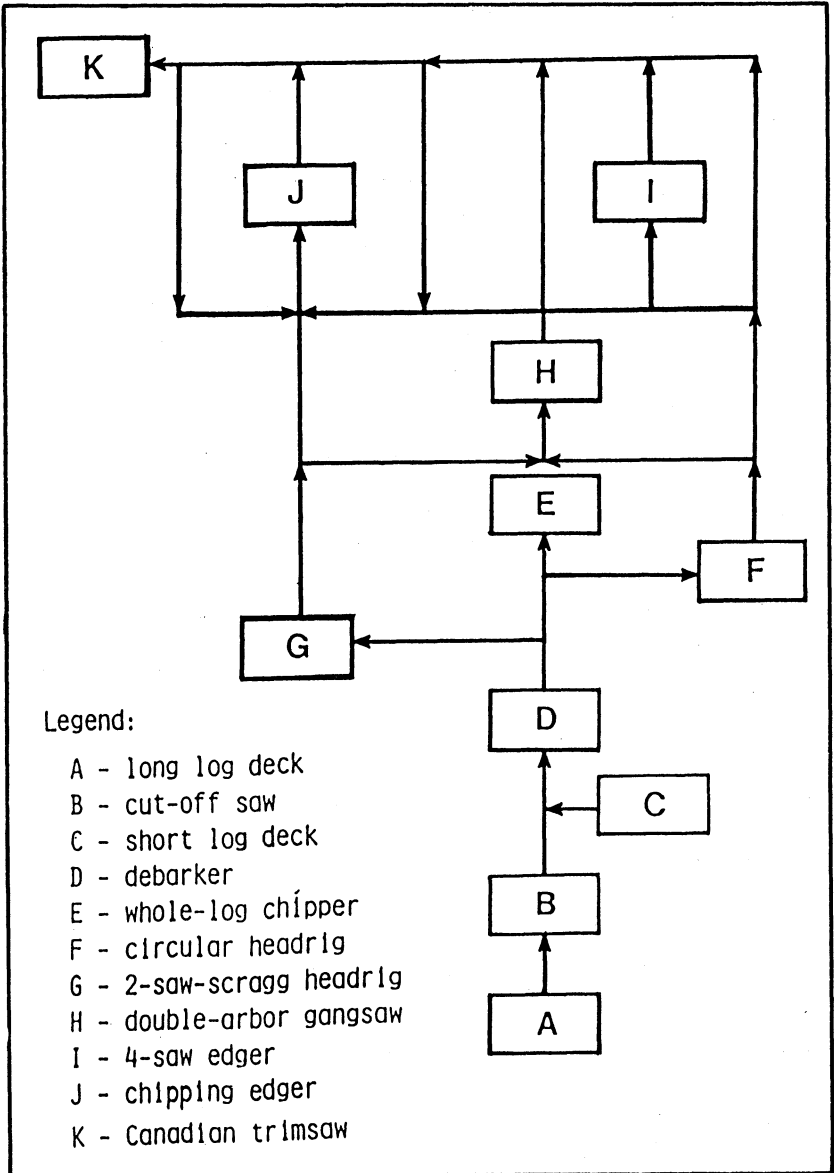


FIG. 2. Simplified mill layout.

dried to about 18 percent moisture content. The narrowest width and shortest length of lumber saved and marketed by the mill are 4 inches and 8 feet, respectively.

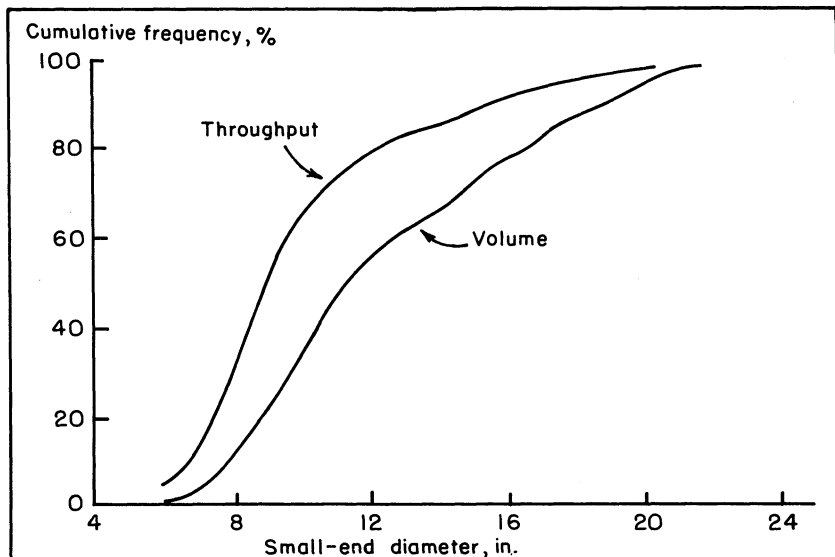


FIG. 3. Cumulative probability distribution of bucked sawlog input based on volume as well as throughput (or piece count).

Objectives of the Study

The study was conducted in order to assist management in answering the following questions:

1. What is the optimum (i.e., profit maximizing) mix of log inputs and lumber outputs for the mill?
2. What is the smallest log that can be profitably processed into lumber at the mill?
3. What process or equipment inhibits higher productivity and what is the impact on profit when its capacity is enhanced?
4. What is the current level of conversion efficiency?
5. How can conversion efficiency be improved (with or without changes in mill equipment or layout)? What is the attainable level?
6. What incremental economic benefits are expected from attainable improvements in conversion efficiency?

Procedure

The procedure discussed in the previous section was followed in this study. However, in formulating the LP model for the mill, it was assumed that there were no product sales restrictions, i.e., the mill had a market for all the items in its current product line. Also, capacity restrictions for the debarker, chipping edger, four-saw edger, dry kilns, and planer mill were

not included because these facilities were obviously being operated far below their capacities. That means only the circular headsaw, scragg saw, circular gang saw, and trimmer were considered in the analysis.

Two LP runs were made. The first run assumed current mill conditions including an uptime of about 80 percent. This will be referred to as Case No. 1. The second LP run (i.e., simulation run) was based on the same assumptions of the first run, except that available log input per hour was increased by 50 percent. This was necessary to force the model to select the "best" logs to process among those available as input to maximize profit. Time study results showed that the bucking and debarking operations could handle such an increase. The second run will be referred to as Case No. 2.

Results and Discussion

Table 1 summarizes the major findings of the LP analysis. It shows the maximum profit contribution or net revenue expected per hour of operation under Case 1 and Case 2. In addition, it shows that the mill seems to be better off economically by not processing logs with small-end diameter of less than 7 inches. The reason for this is two-fold: first, smaller diameter sawlogs have lower net product value yields; second, scarce mill resources, particularly machine time, can be used more profitably by processing larger logs yielding higher-valued products.

TABLE 1. EXPECTED MAXIMUM BENEFITS FROM OPTIMAL ALLOCATION OF MILL RESOURCES.

Item	Case 1	Case 2	Improvement	
			Amount	Percent
Sawlog input per hour				
Processed:				
Minimum small-end diameter (in.)	6	7		
Piece count	145	137	-8	-6
Volume (cunits)	17.5	19.1	+1.6	+9
Rejected ¹ :				
Piece count	None	11		
Volume (cunits)		0.3		
Green chip value (\$)		(20)		
Product yield per hour				
Lumber:				
Quantity (MBF)	15.5	16.9	+1.4	+9
Net revenue (\$)	1,510	1,680	+170	+11
Green chips:				
Quantity (tons)	22.2	22.7	+0.5	+2
Net revenue (\$)	490	500	+10	+2
TOTAL NET REVENUE PER HOUR (\$) ...	2,000	2,180	+180	+9

¹These logs are currently processed by the mill but were rejected by the LP model because these are considered uneconomical to process under current conditions.

In Case 2, there was an expected decrease in throughput (i.e., piece count) of about 6 percent, but log volume input increased by 9 percent, suggesting that bigger logs were used. This would translate into a 9 percent increase (i.e., + 1.4 MBF) in the quantity of lumber recovered or an 11 percent increase (i.e., + \$170) in net revenue per hour. There was also an increase in chip yield of about 2 percent both in terms of quantity (+ 0.5 ton) and net value (+ \$10).

Logs with small-end diameters less than 7 inches represented about 1.3 percent of the total volume input, or 5 percent of the throughput. According to the analysis results, the mill should refuse delivery of long or tree-length logs having top diameters of less than 7 inches. If this is not possible, the mill should convert those undersized sawlogs into marketable chips or sell them as pulpwood or sawlogs to other small-log mills. It was not within the scope of this study to determine the most feasible alternative.

Assuming that the undersized sawlogs were actually chipped instead of sawn into lumber, the expected incremental increase in net revenue per hour was estimated at about \$180 (i.e., 9 percent improvement over the current level). It should be noted that at current market prices for chips and logs, whole-log chipping of sawlogs can only be done at a loss, hence the figure in parenthesis in table 1.

The trimmer proved to be the bottleneck of the production line. The study confirmed earlier observations that it was already operating at capacity, shown in table 2. Most likely, the overall productivity of the mill will improve if trimmer capacity is enhanced.

These results show that through optimal resource allocation, improvement in mill conversion efficiency can be achieved without changing current sawing conditions. In fact, this particular mill's LRF increased slightly from 6.39 to 6.51 when logs with small-end diameters of less than 7 inches were excluded from the input stream, table 3.

TABLE 2. MACHINE CAPACITY UTILIZATION

Case no.	Percent unused capacity			
	Circular headrig	Scragg headrig	Circular gangsaw	Trimmer
1	0	34	22	0
2	0	27	18	0

TABLE 3. EXPECTED INCREMENTAL BENEFITS FROM IMPROVEMENTS IN CONVERSION EFFICIENCY INDICATED BY SIP ANALYSIS

Case no.	Minimum small-end log diameter (inches)	Milling condition code ¹	Lumber recovery		Incremental benefits, \$/hour	
			LRF	Percent improvement	Option 1	Option 2
1	6	A	6.39	—	—	—
		B	6.55	2.5	1	15
		C	6.81	6.6	122	135
		D	6.97	9.1	123	140
2	7	A	6.51	—	—	—
		B	6.67	2.5	2	20
		C	6.94	6.6	138	145
		D	7.10	9.1	140	165

¹Milling Condition Code:

A—Current as in Table 4; with log overlength

B—Current as in Table 4; without log overlength

C—Modified as in Table 5; with log overlength

D—Modified as in Table 5; without log overlength

In addition to the potential increases in net revenue just cited, further increases were obtained by eliminating unnecessary log overlength and by reducing the green target size on the lumber produced. Table 3 shows the expected incremental benefits from such actions.

SIP analysis has indicated that total log overlength on 93 of 100 study logs, excluding top logs, intended for processing at the scragg saw was 35.5 feet. The total log overlength on all of the 100 study logs intended for the circular headrig was 44.2 feet. Usually, a log overlength of 30 feet or less for 100 logs is considered good. Log overlength for the study mill is not far from this benchmark. Nevertheless, log overlength can be further reduced or eliminated through improved bucking practices.

The estimated percent improvements in LRF resulting from the elimination of log overlength are 2.5 percent for Case 1 and Case 2. The corresponding incremental benefit expected under production Option 1 is negligible for both Case 1 (\$1/hour) and Case 2 (\$2/hour). However, under production Option 2, the incremental savings from the elimination of overlength are expected to be \$15 and \$20 per hour for Case 1 and Case 2, respectively.

Table 4 summarizes the milling conditions that existed at the time of the study. The sizing sawing allowances denote the additional amount of wood allowed for thickness and width on the green board to compensate for deviation of the equip-

TABLE 4. WEIGHTED AVERAGE OF ALL BREAKDOWN MACHINES IN THE SYSTEM WITH CURRENT MILLING CONDITIONS.

Nom. in.	Samp. size	Dry dressed 17.% MC	Lumber sizing allowances				Average rough green size	95% skip level
			Dressing	Shrinkage	Sawing	Over-sizing		
	No.	In.	In.	In.	In.	In.	In.	
Thickness								
5/4	100	1.000	0.094	0.038	0.194	-0.057	1.268	1.326
8/4	100	1.500	.094	.055	.205	-.032	1.822	1.854
Width								
4	20	3.500	.094	.124	.223	.303	4.244	4.244
5	20	4.500	.094	.159	.111	.167	5.030	5.030
6	20	5.500	.094	.193	.248	-.002	6.033	6.035
8	20	7.250	.094	.254	.375	.128	8.101	8.101
10	20	9.250	.094	.323	.310	-.053	9.923	9.977
12	20	11.250	.094	.392	.472	-.381	11.827	12.207

ment during sawing. Oversizing is the additional thickness or width on a board that is not needed to satisfy lumber sizing allowances. When oversizing is positive, it means there is excess wood; when negative, it means there is insufficient wood to plane skip free and that more than 5 boards out of 100 in a given size class will plane with skips on them. The current green lumber target size is given under the 95 percent skip level column. SIP analysis revealed that some improvements can be made. Table 5 shows the modified attainable milling conditions. The lumber sizing sawing allowances are the industry norms or averages for similarly configured circular sawmills. In table 5, positive oversizing has been eliminated, but the negative oversizing was retained. If the mill adopts the lumber sizing allowances and green target sets in table 5, the quality of planing should not change. If the present level of planing skips is acceptable, attaining the sizes and allowances shown in table 5 will result in increased recovery with approximately 95 out of 100 pieces planed skip free.

TABLE 5. MODIFIED ATTAINABLE MILLING CONDITIONS

Nominal in.	Dry dressed 18.% MC	Lumber sizing allowances				Average rough green size
		Dressing	Shrinkage	Sawing	Oversizing	
	In.	In.	In.	In.	In.	In.
Thickness						
5/4	1.000	0.078	0.037	0.094	-0.057	1.152
8/4	1.500	.078	.054	.094	-.032	1.694
Width						
4	3.500	.078	.124	.094	.000	3.795
5	4.500	.078	.158	.094	.000	4.830
6	5.500	.078	.193	.094	-.002	5.863
8	7.250	.078	.253	.094	.000	7.675
10	9.250	.078	.322	.094	-.053	9.691
12	11.250	.078	.391	.094	-.381	11.432

Reduction of the green target sets to the level indicated in table 4 could result in a potential improvement in LRF of 6.6 percent for either Case 1 or Case 2. For Case 1, this means a net revenue increase of approximately \$122 and \$135 per hour under Option 1 and Option 2, respectively. For Case 2, incremental net revenue increases of about \$138 and \$145 per hour are expected under production Option 1 and Option 2, respectively.

Potential increases in net revenue under production Option 1, if log overlength was eliminated and the green target sets were reduced to the level given in table 5, would thus total about \$123 and \$140 per hour for Case 1 and Case 2, respectively. Under production Option 2, the total net revenue increase would be approximately \$140 and \$165 per hour for Case 1 and Case 2, respectively.

The results reported suggest that the study mill could realize more benefit from LRF improvement under production Option 2 (i.e., reduced log input for the same amount of lumber output) than under production Option 1 (i.e., increased lumber output for the same amount of log input). Also, more benefits could be derived from the reduction of the green target size on the lumber produced than from the elimination of log overlength.

It should be noted that since trimmer capacity constrains system throughput, increases in lumber volume output resulting from green target size reductions cannot be absorbed by the mill. Trimmer capacity must be enhanced before benefits can be realized from this activity.

Conclusions

It was established that the study mill can realize considerable increases in revenue if the following actions are taken:

1. Only process logs with small-end diameters of 7 inches and over
2. Eliminate log overlength
3. Reduce the green target size of lumber to conform with industry norms

If the mill pursues Action 1 first, followed by Actions 2 and 3, it can realize a maximum net revenue increase of \$345 per hour (i.e., \$180 per hour from 1 and \$165 per hour from 2 and 3). This assumes the mill opts for reduced log input for the same level of lumber output (Option 2). If, instead, the

mill opts for increased lumber output for the same amount of log input (Option 1), the maximum additional increase in benefit derived from 2 and 3 drops to about \$140 per hour. On the other hand, if the mill pursues Actions 2 and 3 and operates without any change in the original log size input distribution, it can realize a maximum net revenue increase of \$123 per hour from Option 1 or \$140 per hour from Option 2.

Eliminating log overlength and reducing green lumber target size are commonly referred to as "tightening-up" projects which normally require no fixed capital investment. The incremental costs and benefits from such projects are realized almost immediately. The expected incremental benefits can appropriately be regarded as the maximum amount that should be spent to pursue such projects to achieve the improvement in conversion efficiency. This means that the mill could improve its profit if the cost of implementing the changes is less than this amount.

The study shows that it pays to consider the evaluation of potential improvements in sawmill conversion efficiency within the profit maximizing framework. Clearly, such an approach will make current SIP efforts consistent with the sawmill owner's primary objective of maximizing the profitability of his mill operation.

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