CEASAW: A USER-FRIENDLY COMPUTER ENVIRONMENT ANALYSIS FOR THE SAWMILL OWNER[1]

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Abstract.--Improved spreadsheet software capabilities have brought optimization to users with little or no background in mathematical programming. Better interface capabilities of spreadaheet models now make it possible to combine optimization models with a spreadsheet system. Sawmill production and inventory systems posseses many features that make them suitable application environment for spreadsheet optimization. This paper describes a spreadsheet model that optimizes log allocation and lumber production.

Keywords: spreadeheet, optimization, bid analysis, log inventory, sawing.

INTRODUCTION

In today's world of advanced technology, many industries have adopted computers to improve efficiency and enhance their business. Some sawmill owners have become interested in the use of computers, not only as an information processing tool, but as a means to help improve their operation and make more efficient use of their resources. However, in spite of the wide acceptance and popularity of computers among many production and manufacturing industries, some sawmill owners remain skeptical and have refrained from adopting any computer-based system.

In an effort to reduce the computer mystique and apparent barrier on the adoption of computers in the sawmill industry, this paper describes a user-friendly computer program purposely designed for hardwood sawmills. CEASAW was developed to assist sawmill owners primarily in two areas: Bid Analysis and Log Inventory.

Before presenting CEASAW, a brief description of earlier work by the authors dealing with computer-assisted production planning in the hardwood industry is provided in the next section. This previous work lead to the development of CEASAW which is discussed in more detail.

EARLIER WORK

Spreadsheet-baaed models have been recognized as a powerful tool in forest production planning (Leefers, L. 1990; Manness, T. 1990; Davis, L.S., F. Schurr, R. Church, and others, 1990). Recognizing the potential of spreadsheet models in hardwood manufacturing, the authors (Mendoza, G., W. Sprouse, W. Luppold, and others, 1990) developed a spreadsheet-based modal called SEASAW (Spreadsheet Environment Analysis for the SAWmill owners). The system was developed with two separate modules: SEASAW and SEAIN. Both modules were developed within the Lotus (1985) environment and are menu-driven. Due to some limitations in programming Lotus'a Macros, and restrictions for future expansion and improvements of the two modules within the Lotus spreadsheet environment, another software was developed, namely CEASAW. Both systems (i.e. SEASAW and CEASAW) are similar in that they can both perform tree (or stumpage) sale analysis and log inventory. The major difference in these two systems is the software requirements. SEASAW requires that the user has the Lotus spreadsheet program while CEASAW is a stand alone, Pascal coded program, requiring no other software to run. Both systems have their advantages and disadvantages.

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Since SEASAW operates under Lotus environment, there are many built in advantages to this system. SEASAW can take advantage of these inherent capabilities and desirable features of Lotus spreadsheet, such as: 1) relative ease of operation, 2) use of traditional scheme for entering information in a" row-and-column format, and 3) highly convenient user-oriented environment, relying on menus, built-in mathematical and statistical functions, including graphics. CEASAW, on the other hand, is an executable stand alone program which does not require Lotus, or any other software. At the present time, CEASAW has no graphic capabilities and statistics are limited to maximum, minimum, and average values. Future enhancements of CEASAW will include export capabilities for outputing ASCII files for further processing.

CEASAW

Computer Environment Analysis for the Sawmill owner or CEASAW was developed as a management tool to assist sawmill owners or managers in making better decisions and production plans. The program is a part of a larger system currently being developed involving a computer-assisted decision support system for the primary processing of hardwood trees. In running CEASAW, the user is lead through the program by a series of menus and prompts providing for a very convenient, easy and friendly user environment. A schematic diagram of CEASAW is shown in Figure 1.

Currently, CEASAW has four main modules: (1) Bid Analysis, (2) Inventory Set-up, (3) Log Inventory, and (4) Help Modules. The following sections describe the first three main modules briefly.

<u>Bid Analysis</u>

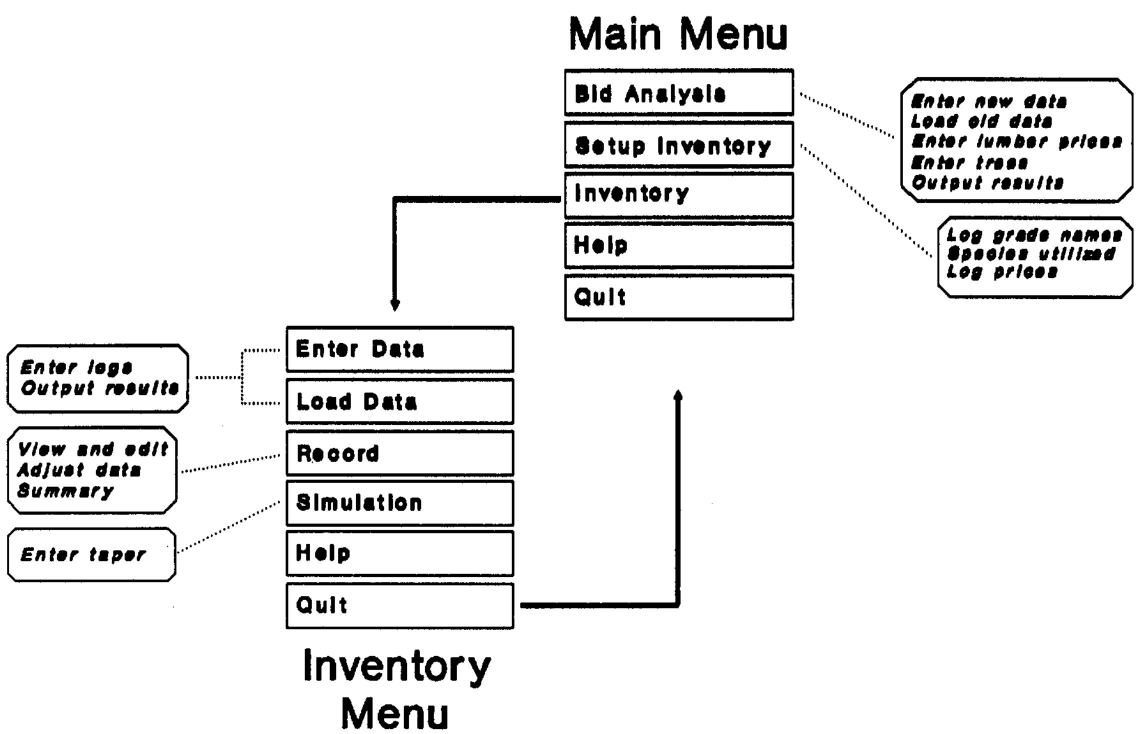
The Bid Analysis Module estimates the amount of lumber conversion by grade and species from each of 17 hardwood timber species. This module is based on the conversion rates reported by Hanks (1976). The rates are estimated for each lumber grade using a regression model:

$$VOL = a + b_1*DBH^2 + b_2*HT + b_3*(DBH^2*HT)$$

where a, b_1, b_2, and b_3 are regression coefficients; DBH is the diameter (in inches), and HT is the height (in feet). Using the estimated volume and given the estimates of lumber prices, the value of a tree or a woodland may be estimated.

After choosing the Bid Analysis module, the user is prompted with the option to either "Enter Data"(thru the keyboard) or "Load Data" (previously created data on file). The user can view, edit, and save the data as needed. Before entering the data (consisting of coded species and grade, DBH, and height), the user has the option to enter or edit lumber prices by species and grade.

Figure 1: Computer Environment Analysis for the Sawmill (CEAsaw)



A complete summary report is shown on the screen while a copy is sent to a file named by the user. Also, there is an option to send a copy to the printer. Table 1 shows an example of the first summary table. This table shows tally information by species and tree grade. Table 2 is also an example of the volume report for each species present during the analysis. Lumber volumes are in board feet while lumber cost or value are estimated assuming lumber price of one dollar per board feet. These prices figures are hypothetical and were used primarily for developmental and illustrative purposes.

CEASAW Inventory Setup

The Inventory Setup Module is used to initialize the Inventory Module. The user enters the log grades used by his/her mill and the prices for each species. CEASAW allows for 15 log grades. The program refers to these log grades during calculation as numbers 1 to 15. However, for reports and input entry, the log grades are referred to by the names entered in the Setup Module. Also, the user could set up the program using his own grading system. Next, the user is asked to pick the species used by the mill from the list of 17 possible species.

Table 1: Bid Analysis Summary Table

CEAsaw Summary Statistics

Species Code	Species Name	Total Number	Grade 1	Grade 2	Grade 3
1.	Black Cherry	3	1	1	1
2.	N. Red Oak	1	0	1	0
3.	Black Oak	2	0	1	1
4.	White Oak	2	1	0	1
5.	Yellow Poplar	2	1	1	0
6.	Red Maple	2	0	1	1
7.	Basswood	2	1	0	1
8.	Sugar Maple	2	1	1	0
9.	Yellow Birch	1	0	0	1
10.	Paper Birch	1	1	0	0
11.	Chestnut Oak	1	0	1	0
12.	Black Walnut	1	0	0	1
13.	Ash	1	1	0	0
14.	Hickory	1	0	1	0
15.	Elm	1	0	0	1
16.	Scarlet Oak	1	1	0	0
17.	Beech	1	0	1	0
	Total Number of Trees =	25	8	9	8

Table 2: Bid Analysis Summary Table

CEAsaw Volume Summary
BLACK CHERRY

	--------- tree grade ---------				
	Grade 1	Grade 2	Grade 3	Lumber (Bd ft)	Lumber Value (@ $l/bd ft.)
FAS	62.26	0.00	5.26	67.51	67.51
FAS1F	0.00	0.00	0.00	0.00	0.00
selects	0.00	6.58	10.65	17.23	17.23
saps	0.00	0.00	0.00	0.00	0.00
No. lC	0.00	26.37	15.57	41.93	41.93
No. 2A	0.00	0.00	0.00	0.00	0.00
No. 2B	0.00	0.00	0.00	0.00	0.00
No. 2C	0.00	19.43	16.69	36.12	36.12
SW	0.00	0.00	0.00	0.00	0.00
No. 3A	0.00	3.73	4.27	8.00	8.00
No. 3B	30.87	0.00	1.99	32.86	32.86
No. 3C	0.00	0.00	0.00	0.00	0.00
TOTALS	93.13	56.10	54.43	203.66	203.66

This helps limit the input of prices to only those species utilized. The program will alert the user if he enters a species in the inventory module that has not been marked as being utilized. This avoids invalid or missing prices. After the initial setup, the user does not need to enter the Setup Module again until information, such as prices, are changed.

CEASAW Inventory--Enter Data

When the inventory module is picked from the main menu another menu is displayed. Within the Inventory Module there are three options, Enter data, Load data, and Record.

Enter data allows the user to enter inventory data at the keyboard, within CEASAW, one log at a time. When using this option, the user is prompted for some identification information so that each log can be referenced appropriately. The user has the option to use these optional information or leave them blank. These information are used later in the summary section under the Record option. An output file is named which will contain tree number, DBH, length, volume, and cost.

Figure 2 shows an example of the first input screen displayed when Enter Data is chosen. The current log number and the last log number are shown. This is done automatically by the program. A file is created containing the last log number entered during the last session. Each time the Enter Data option is picked, the file is read and the log numbers are changed automatically. This option is provided for-the sawmill owner who wishes to perform conversion studies of the logs in the inventory (i.e using Bid Analysis option), or simply to keep an accurate record of log inventories. If the logs are not tagged as they come into the yard the log number can be ignored.

Once the data for one log has been entered the user has the option to quit, edit the current entry, or continue. Once all of the logs have been entered a summary of the session is displayed on the screen. Figure 3 gives a summary of the log size as well as a tally of the species. A similar table is displayed which gives a tally by log grade. These tables may be sent directly to a printer.

Figure 2: ENTER INVENTORY DATA SCREEN

```
output file = test.out

                              Last Input
 130            4              1          18          24
  Log number     Species        Grade       DBH       Length
 --------------------------------------------------------------

 131

                  PLEASE USE THESE SPECIES CODES
1 = BLACK CHERRY         8 = SUGAR MAPLE        15 = ELM
2 = NORTHERN RED OAK     9 = YELLOW BIRCH       16 = SCARLET OAK
3 = BLACK OAK           10 = PAPER BIRCH        17 = BEECH
4 = WHITE OAK           11 = CHESTNUT OAK
5 = YELLOW POPLAR       12 = BLACK WALNUT
6 = RED MAPLE           13 = ASH
7 = BASSWOOD            14 = HICKORY
```

Figure 3: Summary Table

```
                    CEAsaw Mill Inventory Summary

Mon., Aug. 27, 1990                              OPERATOR : BILL
FILE : test.out            LOAD # : A            I D # : B

TOTAL NUMBER OF LOGS...      4
TOTAL VOLUME (DOYLE) ...  192.00
TOTAL COST ............     0.00

MAX DBH...............    12.00        MAX LENGTH...........    12.00
MIN DBH...............    12.00        MIN LENGTH...........    12.00
AVERAGE DBH...........    12.00        AVERAGE LENGTH........   12.00

*************************** SPECIES COUNT SUMMARY ************************

     BLACK CHERRY....4
```

CEASAW Inventory--Load Data

The Load Data option is very similar to the Enter Data option. Load Data will import an ASCII file for the inventory data. The only difference is that the log number is read from the input file and is not entered by the program. It is suggested that the Enter Data Option be used in order to track logs more accurately.

CEASAW Inventory--Record

The Record option allows the user to perform a number of summaries of the data already entered into the program files. This option also allows the user to look at an individual record entered and to adjust data from logs to lumber. Adjusting logs to lumber keeps accurate inventory of logs remaining in the yard and those logs which have been milled.

Summaries can be done by a particular day, week, month, year, load number, identification code, or all of the data in the file. The summaries are then displayed once the data has been read and the summary statistics calculated.

A PROTOTYPE SPREADSHEET OPTIMIZATION MODEL

End user optimization is becoming more widespread. Current software that links optimization with spreadsheet systems now make it possible for a user with limited or no quantitative analysis background to develop useful management decision tools utilizing optimization or mathematical programming. One example of this commercially available spreadsheets with optimization capability is QUATRO-PRO (1990).

The use of mathematical models in various aspects of forest products manufacturing is well described in the literature. Various types of optimization models have been developed for log bucking (Pnevmaticos and Mann, 1972; Eng, G., H.G. Dallenbach, and A.G.D. Whyte, 1986), log allocation (Mendoza, G. A and B.B. Bare, 1986); and lumber manufacturing (B. Faaland and D. Briggs, 1984).

One of the major stumbling blocks in adopting these mathematical models as decision aids for the forest products industry stems from the amount of mathematical rigor required by the models. To install and make effective use of these models would require a staff of technically trained personnel, which is often beyond what most forest product firms can afford. To help alleviate this problem, a spreadsheet-based optimization model for hardwood sawmills was developed as described in the next section. The model is still in developmental stage but initial results appear very encouraging.

The prototype spreadsheet optimization model was developed using QUATPO-PRO. It should be noted that the spreadsheet optimization model is just one of a number of components or modules within an integrated decision support system currently under development which covers a wide range of manufacturing aspects such as: bid Analysis, log Inventory, sawmill design, simulation and optimization.

In developing the model, it was necessary to make all programming transparent to the user in order to relieve him of the intricacies of data manipulation and model building. While it is desirable to make the model totally menu-driven, it was not possible to develop a “generic” as well as a flexible model that could be used by different end-users. This is especially true in an optimization environment where the parameters and the scope of the problem to be optimized must be well-defined. Sawmills have different lay-outs, including other physical attributes and operational environments. To make the model more relevant, and at the same generic and flexible enough to accommodate various manufacturing conditions, it was necessary to develop "modular" optimization models, where each module addresses a more specific manufacturing scenario. One of the modules already developed is the Log Allocation Module described below:

Log Allocation Module

This module was developed to address a log allocation problem typically found in many sawmills. One of the concerns in lumber manufacturing is what log mix should be processed to meet a lumber demand on a daily or weekly basis. It is also common among sawmills to merchandise their logs instead of processing them into lumber. Hence, sawmill managers are often faced with the problem of deciding what type of logs (by species, grade and size) should be allocated to the log market for merchandising, and what mix of log input (by grade, species and size) should be processed to meet actual and projected demands for various lumber products.

This log allocation problem for a given species, can be simply described as a mathematical programming problem as follows:

$$\text{Maximize } R = \Sigma P_k Y_k - \Sigma C_{ij} X_{ij} + \Sigma M_{ij} Q_{ij}$$

$$\text{s.t. } Q_{ij} + X_{ij} \le L_{ij} \quad \text{for all i,j}$$
$$Y_k \le D_k \quad \text{for all k}$$
$$\Sigma \Sigma r_{ijk} X_{ij} - Y_k = 0 \quad \text{for all k}$$

where: R = economic return
P_k = price of lumber grade k
C_{ij} = cost of processing (sawing) log grade i of size j
M_{ik} = price of log grade i, size j sold in the market
Y_k = amount of lumber grade k produced
Q_{ij} = amount of log grade i, size j sold in the market
X_{ij} = amount of log grade i, of size j sawn
L_{ij} = amount of log grade i, of size j. stored in the inventory
D_k = estimated demand for lumber grade k
r_{ijk} = lumber recovery rate in percent, of processing log grad i, size j, into lumber product k

Interfacing CEASAW with Spreadsheet Optimizer

The interface capabilities of QUATRO-PRO provides a very convenient way of combining CEASAW with the log allocation optimization module described above. The structure of this interface is described in Figure 4.

The subprogram CEAOpt basically constitutes the vehicle that interfaces CEASAW and QUATRO-PRO. CEAOpt takes the information from CEASAW, specifically through the Log Inventory and Lumber Conversion, then systematically derive the conversion rates and log availability for each species and grade. These information will provide values for L_{ij} and r_{ijk} in the log allocation module. CEAOpt automatically creates an input file for subsequent optimization. A separate input file can be created for each species. These input files are designed and created so that they are compatible with the format required by QUATRO-PRO Optimizer. CEAOpt requires from the user information on prices of log and lumber products, processing and procurement costs, and expected demand for log and lumber products. Other than these pieces of information which are entered interactively by the user, the program is automated through menu-driven user-specified options eliminating any programming or data manipulation requirement from the user.

At this time, the output processor is still under development. Efforts are underway to design the output so that only relevant and useful information are displayed and summarized.

CONCLUSIONS AND FUTURE DEVELOPMENT

CEASAW offers an easy to use program that the sawmill manager can use to estimate lumber conversion as well as keep track of the log inventory. The program is completely operational although further testing is still being conducted. At the same time, refinements and further developments on the program are in progress. As previously stated, CEASAW is a part of a larger system designed as an integrated decision support system for hardwood sawmills. Besides CEASAW, a sawmill simulator has also been developed as an integral part of the decision support system. CEASAW can now be interfaced or linked to the simulator. Besides interfacing CEASAW with the simulator, it can also be linked to an optimization program using QUATRO-PRO. This optimization program is designed to provide the user with the capability to allocate and process available raw materials into final products in the most efficient manner.

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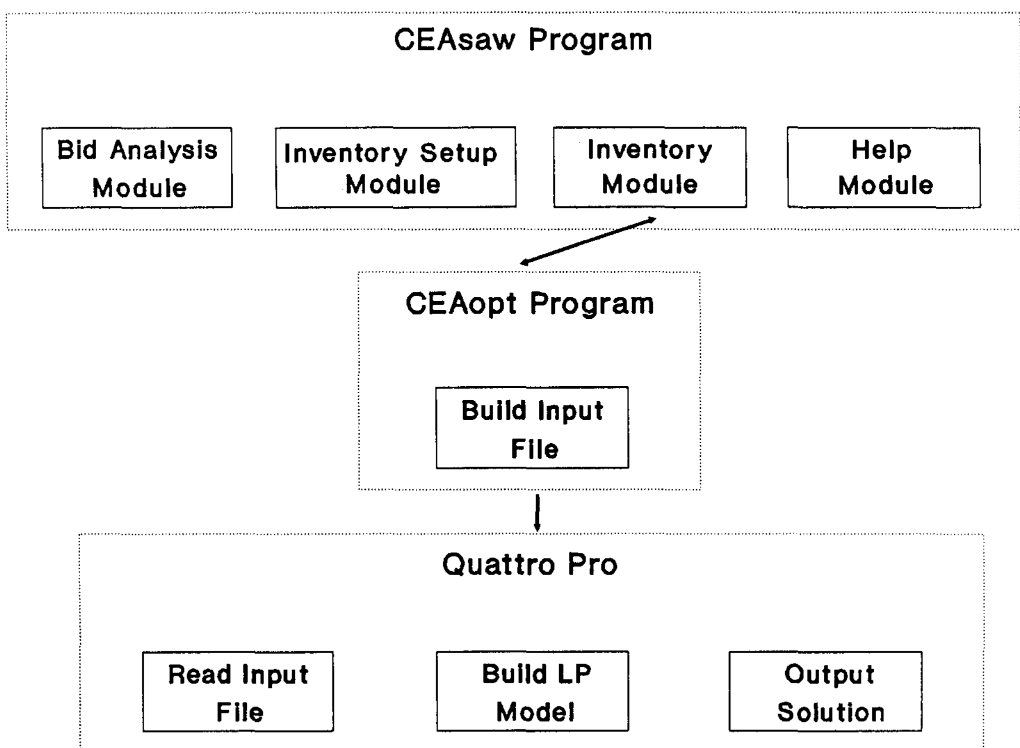
Figure 4: Link between CEAsaw, CEAopt, and Quattro Pro



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