by Edward L. Adams
and Daniel E. Dunmire

SOLVE II USERS MANUAL:

A PROCEDURAL GUIDE FOR A SAWMILL ANALYSIS

FOREST SERVICE GENERAL TECHNICAL REPORT NE-44
1978
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
370 REED ROAD, BROOMALL, PA 19008

The Authors

EDWARD L. ADAMS is a market analyst for the Forestry Sciences Laboratory at Princeton, West Virginia. He received a bachelor of science degree in forest management and a master of science degree in forest mensuration at West Virginia University. He worked for the Forest Service in Oregon from 1960 to 1963 and joined the Northeastern Forest Experiment Station in 1968.

DANIEL E. DUNMIRE is leader of the Processing Team, Resource Use, at the Northeastern Area, State and Private Forestry, in Broomall, Pennsylvania. As team leader, he directs technical assistance activities in log and lumber processing through state forest products utilization programs. He has authored several publications on wood processing. He graduated from West Virginia University in 1957 and studied at Southern Illinois University where he also taught wood treating and drying.

MANUSCRIPT RECEIVED FOR PUBLICATION 31 JANUARY 1978

ABSTRACT

A procedural guide for using the SOLVE II computerized technique for analyzing hardwood sawmills. Included are discussions of: (1) analysis design, (2) data collection, and (3) computer card preparation and use. By following this guide, sawmill analysts should have little difficulty in using the technique.

SOLVE II USERS MANUAL:
A PROCEDURAL GUIDE FOR A SAWMILL ANALYSIS

CONTENTS

FOREWORD

This is the second of a series of five papers on the use of the SOLVE II concept for analyzing hardwood sawmills. The first paper explains what the computerized SOLVE II technique is and what it does. This paper will explain a step-by-step procedure for collecting and preparing the data for computer use. The third paper will document the computer program and explain the procedures used. The fourth paper will explain how the SOLVE II results (outputs) may be used to analyze a sawmill. And, the fifth paper will provide standards, developed from the SOLVE II analysis of 70 mills, that may be used to judge the efficiency of specific mill types. Readers are alerted to save copies of each of these papers so that they can be kept together for future reference.

INTRODUCTION

"SOLVE II: A Technique to Improve Efficiency and Solve Problems in Hardwood Sawmills",[1] provides and overall look at the technique. It covers the input data, the resulting output information, and application of the results. This paper provides a systematic procedure for collecting and processing the data required for a SOLVE II analysis.

The SOLVE II sawmill analysis technique will work for most hardwood sawmills. It has been designed to accept:

- Any number of species.
- Five log grades within a species for any log grading system.
- Up to 500 study logs within a species.
- Log scale based on the International 1/4- inch, Doyle, Scribner Decimal C, or Vermont log rule.
- Ten lumber grades.
- Lumber thicknesses from 2/4 to 8/4 inches. Greater thicknesses can be accepted by adjusting the surface measure of the lumber. For example, a 16/4-inch board with a surface measure of 20 square feet is equivalent in volume to an 8/4-inch board with a surface measure of 40 square feet.
- Up to 8-inch special products (ties, timbers, cants, etc.). Greater thicknesses can be accepted by adjusting the surface measure of the product.

Not only can the technique be used for most hardwood sawmills, but it is computerized to minimize the work needed in the analysis. Once the data are recorded for a given sawmill, they are transferred to computer cards. No hand calculations are necessary.

[1] Adams, Edward L., and Daniel E. Dunmire. 1977. SOLVE II: A technique to improve efficiency and solve problems in hardwood sawmills. U.S. Dept. Agric. For. Serv. Res. Pap. NE-382. 19 p.

The computer card deck for SOLVE II consists of 14 components as shown in Figure 1. Notice that components 4 through 14 are repeated for each species, components 9 and 10 are repeated for each log grade within a species, and components 12 and 13 are repeated for each log.

This manual covers the development and use of the components, and is divided into three sections: (1) analysis design, (2) data collection, and (3) computer card preparation and use. You will find that, following the instructions given in these three sections, the SOLVE II technique is not difficult to use. However, representatives from the Northeastern Area State and Private Forestry who work through the utilization foresters of many northeastern states, provide assistance to individuals who wish to use the SOLVE II technique. Experience has shown that after participating in one complete SOLVE II study, a sawmill analyst will have the ability to work independently on future studies.

I. ANALYSIS DESIGN

Data collection for the SOLVE II technique is very important. The saying "garbage in, garbage out" is especially true of the SOLVE II computer program. In other words, if poor or insufficient data are fed in, the resulting output can be misleading or incorrect. To minimize this problem, a systematic procedure should be used. We recommend the following:

- Study the layout of the mill.
- Obtain the preliminary data for components 2 through 10.
- Select, measure, and grade the study logs.
- Test run a few nonstudy logs through the mill to ensure that you have enough men in the right places to collect all of the necessary data.
- Process and collect the data on the study logs.

You will find a detailed discussion of this procedure in the following sections. If carried through,

our procedure should give satisfactory results for your sawmill analysis.

Mill layout

When you study the layout of the mill, keep in mind that each board must be identified with the log from which it was sawed. In small mills, the lumber inspector may be able to identify the boards as they are produced. In other mills, it will be necessary to write a number or use a color code on both the log and the boards. In either case, men must be positioned where they can number or code each board as it is produced. This usually requires men at the headsaw, resaw, and trimmer; in high-speed mills, two men may be needed at some stations.

Besides the men used to mark the boards, several more are needed. One man is needed to read the log number or color code and post it on a blackboard so that crew members can identify the log being processed. Another man is needed to take sawing times. Two men will probably be needed on the green chain—one to inspect and one to tally the lumber. An extra man should also be available to assist where needed.

One man is needed to supervise the entire operation. He ensures that things run smoothly and that the data are collected accurately. He should also note mill situations that might affect the operation. These notes can be valuable in analyzing the results.

Preliminary data

Preliminary sawmill data are required for components 2 through 10 of the card deck. The information for components 2 through 6 must be supplied by the mill manager or his representative. Here again, it is absolutely necessary that the information be as accurate as possible. Errors in such things as mill operating cost or average productive headsaw time per day can cause considerable error in the economic analysis of the results.

Components 7 through 10 are used for expected lumber grade yields that may be compared with the mill's actual yields. The mill manager will not usually have this information. However, expected yields for many species are available in published reports such as FPL-63.[2] Much of the information in FPL-63 has been updated by the Grade and Quality of Hardwood Timber Project (Work Unit 3102) of the Northeastern Forest Experiment Station at Delaware, Ohio. This information is on file with the Northeastern Area State and Private Forestry.

But if the FPL-63 or updated yields are used, the Forest Service Factory Log Grades[3] must be used. When a different grading system is used, the expected yields must be based on that system. In either case, care must be taken to ensure that the expected yields are representative of what the mill manager should expect from his mill. When satisfactory expected yields are not available, the yield comparison can be eliminated by entering the proper code on component 7 and omitting components 8 through 10.

Study logs

To determine the number of species to be used in a sawmill analysis, keep in mind that it is better to sample a large number of logs for one or two major species than to sample a few logs for each of a large number of species. If you can only afford to sample approximately 300 logs, you will get better results if you use only one species.

After the species is chosen, you must determine how many study logs are needed in each log grade and how you are going to select them. In the first SOLVE II publication, a sampling scheme was discussed that called for sampling four logs in each size class within a log grade and species. Although that scheme will provide satisfactory results, the following sampling method is recommended. It allows you to pick a sample size relative to the error, in dollars, that is acceptable in both the maximum sawlog value table and the zero profit log value table.

To use this sampling method, you must first decide how to pick the study logs. They can be picked at random or taken mill run as they come from the log storage area. Regardless of how the logs are picked, have them brought to an area where they can be stored until you are ready to process them. As the logs arrive, have them measured, scaled, graded, and numbered. Also keep a dot tally of the logs by diameter and even-length classes for each log grade as shown in Figure 2.

[2] Vaughan, C. L., A. C. Wollin, K. A. McDonald, and E. H. Bulgrin. 1966. Hardwood log grades for standard lumber. U.S. Dep. Agric. For. Serv. Res. Pap. FPL-63. 52 p.

[3] Rast, Everette D., David L. Sonderman, and Glenn L. Gammon. 1973. A guide to hardwood log grading. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. NE-1, rev. 32 p.

Even-length classes as used here mean 8-, 10-, 12-, 14-, and 16-foot lengths. Odd-length logs would be rounded down to the next even-length class. In other words, a 9-foot log would be dot tallied in the 8-foot length class. Although this log would be tallied in the 8-foot class, the length would still be recorded as 9 feet on the sawlog data sheet. (Fig. 7).

Each combination of diameter and length class in Figure 2 makes up a size-class cell. In other words, the 8-inch diameter class within the 8-foot length class makes up one cell and the 8-inch diameter class within the 10-foot length class makes up another. As the logs are dot tallied in these cells, periodically count the number of cells that contain at least one dot. Divide this number into the total number of study logs in the grade to determine the average number of logs per size class in the sample. Enter this average on Table 1 to estimate the maximum error that can be expected 95 times out of 100 if this sample size is used.

Table 1.—Error in dollars for given average number of logs per size class

Average number logs	Error (dollars per MBF)
2	26
3	18
4	14
5	12
6	10
7	9
8	8
9	7
10	7

For example, if for a given grade and species of sawlog you have a total of 60 logs that are distributed over 10 cells, you have an average of 6 logs per size class. In Table 1, you will find an error of $10 per MBF for this sample size. This means that if you ran an analysis with this 60-log sample, the value of the average size log in both the maximum sawlog value table and the zero profit log value table would not be off more than $10 per MBF (95 times out of 100).

This procedure should be continued until the sample size is sufficient to indicate a satisfactory error in Table 1. An error of $10 per MBF should be satisfactory for most applications.

One additional thing should be considered: in both the calculation of the average number of logs per size class and the final selection of the logs to be used in the study, logs should be grouped by size class. A few large logs should not be included in a sample of small logs. If there are only a few logs in a length class, they should also be excluded. For example in Figure 2 the log in the 14-inch diameter class and the two logs in the 15-inch diameter class should be excluded. The three logs in the 16-foot length class might also be excluded. A few logs outside of the general size classes can have an adverse effect on the results.

Grouping the logs by size class will not always be easy. In the example shown, some analysts might feel that the two logs in the 10-inch class should be excluded and the three logs in the 16-foot class should be included. These are decisions that the analyst must make based on his knowledge of the effect that changes in log diameters and lengths have on the mill's production and yield. However, if there is a question about a given size class, it should be included in the study. Then, after the data have been processed by the SOLVE II computer program, the questionable log data can be checked in the computer outputs. These outputs include graphs showing plots of both the data points and the resulting regression lines for sawing times, board foot yields, and dollar yields for the study logs. If these graphs show that the questionable log data do not fit the general trend of the other data, these data cards should be removed and a new computer run made.

Test run

Before you saw the study logs, make a test run. First, make sure that the mill is in good repair. Also make sure that the men operating the various pieces of equipment are the regular operators.

When your crew and the mill are ready, number a few nonstudy logs and have them processed through the mill. This will give you a chance to see that your men are positioned properly and to ensure that each knows his job. Some adjustments may be necessary during this test run.

Processing

After you have test run enough logs to ensure that your crew is ready, have the mill process the study logs. While collecting the data, each recorder should note any unusual occurrence that might affect the results. This would include such things as board lost to the chipper, unnumbered

boards, cause of unusual delays, and sawing problems. This can help explain irregularities that may be found later.

As mentioned earlier, it is important to have a study supervisor watch the entire operation. He should look for milling practices that might affect such things as overrun, lumber-recovery factor, lumber grade yield, production rate, and downtime. This type of information can prove valuable when the study results are analyzed.

II. DATA COLLECTION

This section provides a detailed discussion of each SOLVE II component plus example data sheets for recording the information. As an aid in the transfer of information from the data sheets to computer cards, card column numbers are shown on the data sheet for each item.

Component 1 - computer program

The SOLVE II computer program processes the input data to provide the analysis results. You can obtain this program card deck and a test data deck from NA-S&PF, Forest Service, 370 Reed Road, Broomall, PA 19008.

Component 2 - sawmill name card

This card requires the following information. Figure 3 (Basic Mill Data Sheet) shows how to record this data.

1. Sawmill name — the name or identification code of the sawmill for which the analysis is to be run.

2. Number of species — the number of different species that are to be used in the analysis.

Component 3 - sawmill data card

This card requires the following basic information. Figure 3 shows how to record this data.

1. Month — date of the analysis.
2. Day — date of the analysis.
3. Year — date of the analysis.
4. Operation cost/minute — to determine this cost for the sawmill, you must divide the total yearly operating cost by the total number of minutes the mill was in operation during the year. Both the cost and operating time must be determined as accurately as possible.

   The total yearly cost must include all operating costs incurred by the sawmill from the log yard to the lumber loaded for shipment. Make sure you include the cost for all salaries, wages, FICA taxes, employment security, workmen's compensation, group insurance, travel expenses, advertising, depreciation, interest, taxes, power, supplies, repairs, and maintenance. Do not include the broker fee for selling lumber in this cost—it is entered later. Also make sure that you do not include the cost of sawlogs or the cost of other operations not directly related to the sawmill, such as logging or hauling. If part of the overhead cost is related to other operations, prorate that part pertaining to the mill.

   The total yearly operating time in minutes includes the total time that the sawmill was in operation during the year. For a sawmill that works five 8-hour shifts per week, the maximum yearly operating time would be 124,800 minutes. If the sawmill takes a week's vacation, this figure would be reduced by 2,400 minutes. This figure would be reduced further for abnormal downtime when the mill is closed due to such things as extremely cold weather, fire, or major repairs.
5. Green chip price/ton (f.o.b. mill) — the price received by the sawmill for its green chips.
6. Mill type code — this code is used to identify the type of mill being analyzed. The codes are:

   1. Band.
   2. Circular.
   3. Scragg.
   4. Circular w/resaw.
   5. Band w/resaw.
7. Profit margin (percent) — this is the profit margin that the mill manager wishes to make. It is based on a percentage of potential sales (product value).
8. Risk margin (percent) — this is the margin that the mill manager feels is necessary to cover the risk that occurs when he buys logs today and sells the lumber from those logs some time in the future. If the lumber is air dried, this may be 6 months to 1 year later. The risk margin is also based on a percentage of potential sales (product value).

9. Broker fee (percent) — the percentage of the lumber value paid to a lumber broker as his fee for selling the lumber.
10. Cash discount (percent) — the percentage of the lumber value allowed the lumber buyer for prompt payment of his bill.
11. Average productive headsaw time/day — the long-range average number of hours per day that the headsaw is actually operating. Normal downtime for such things as work breaks, saw changes, minor repairs, and minor adjustments must be reflected in this average time per day.
12. Average number of hours worked per day — the average number of hours that the mill operates per day. The time would be 9 hours for a mill that works one 9-hour shift per day.
13. Log rule code — this code indicates the log rule used by the mill. The codes are:
    1. International 1/4 inch.
    2. Doyle.
    3. Scribner Decimal C.
    4. Vermont.

Component 4 - species control card

This card requires the following information. Figure 4 (Basic Species Data Sheet) shows how this information is recorded.

1. Species name — the name of a species being studied.
2. Log grading system code — this code indicates whether the USFS factory log grading system is to be used in the analysis. The codes are:
    1. USFS factory log grading system.
    0. Any other log grading system.
3. Sawing time regression code — this code indicates whether the sawing times are to be curved (regressed) by log grades or for all grades combined. When the analysis is to be made on only a few size classes in each log grade, the sawing times should be curved for all grades combined due to the small sample size. The codes are:
    1. Sawing times regressed for all log grades combined.
    0. Sawing times regressed by log grades.
4. Output by log grade code — this code indicates whether you want the output for each log grade or for all grades combined. The codes are:
    1. Output shown for all log grades combined.
    0. Output shown by log grade.
5. Log length code — this code indicates whether the log length measurements are to be taken to the nominal foot or nearest 0.1 foot. The codes are:
    1. Log length measured to 0.1 foot.
    0. Log length measured to the nominal foot.
6. Lumber degrade factor — this is used to adjust for the reduction in dollar value caused by degrade and shrinkage that occurs when lumber is dried. The factor is determined by subtracting the percentage of loss of green lumber value from 100 percent. If the mill is selling green lumber, the factor will be 100. If a mill sells dry lumber and usually sustains a 3 percent loss in value due to degrade and shrinkage, the 3 percent would be subtracted from 100 percent to provide a lumber degrade factor of 97.

Component 5 - lumber grade title card

This card requires titles for the lumber grades that are cut by the sawmill. Figure 4 shows how this information is recorded. Space is available for up to 10 lumber grades plus special products (ties, timbers, cants, etc.). All spaces do not have to be used. The title for each grade can have from one to four letters and/or numbers.

Component 6 - lumber price cards

Current lumber prices are recorded on the lumber price cards as shown in Figure 4. *All 7 cards are required even if the prices on some of them are "0".* The lumber grade numbers shown on the data sheet for this component correspond to the lumber grade numbers in component 5. If the title for FAS lumber is entered under Grade 1 in component 5, the prices for FAS lumber must be entered under lumber grade 1 in this component. Special product (ties, timbers, cants, etc.) prices must be recorded under lumber grade 11. The information that must be entered on these cards consists of:

1. Species identification — these are the initials to identify the species for which the lumber prices are given.
2. Lumber thicknesses and prices — lumber thicknesses are recorded in 1/4 inches for lumber grades 1 through 10, and in inches

for grade 11. For example, on the first card, a 2 is entered under thickness. This represents 2/4- inch lumber (grades 1 through 10) or 2-inch special products (grade 11). The prices are entered in dollars per MBF by lumber thickness and grade.

The examples shown for components 5 and 6 in Figure 4 are self-explanatory. But what if the mill is also cutting pallet lumber (7/8 to 1 inch) and pallet stringers (2 to 4 inches)? Where would the price per MBF be entered in component 6? Since the pallet lumber is sold as 4/4-inch lumber, the price per MBF could be entered on the 4/4-inch card under grade 6. The price per MBF for pallet stringers could be handled in either of two ways. It could be entered on the 8/4-inch card under grade 7, or it could be entered on the 2/4-inch card under grade 11. Remember that when using lumber grade 11, the 2/4-inch card represents 2-inch thick products.

Component 7 - expected lumber yield code card

This code indicates whether expected yields are going to be included as input data. The proper code activates the computer to compare the actual lumber yields with expected yields. Figure 5 (Expected Lumber Yield Data Sheet) shows how this information is recorded. Notice that a separate code is entered for each log grade. The codes are:

1. Expected lumber yields to be entered as data.
0. Expected lumber yields not to be entered as data.

Component 8 - expected lumber yield grade title card

This card requires the titles for the lumber grades used in component 10 for the expected lumber yields. If expected yields are not used, omit this card. Title for each grade can have from one to four letters and/or numbers. Figure 5 shows how this information is recorded.

Component 9 - expected lumber yield control card

This card is not required if expected yields are not entered as data. If expected yields are used, the following information is required as illustrated in Figure 5:

1. Species name — the name of the species for which expected yields are given.
2. Log grade — the log grade for which expected yields are given.
3. Lower diameter limit — this is the smallest diameter for which expected yields are given.
4. Upper diameter limit — this is the largest diameter class for which expected yields are given.

Component 10 - expected lumber yield cards

The yield cards require the following information for each diameter class for which lumber yields are given. Figure 5 shows how this information is recorded. Each line on the data sheet represents a card. If there are no yields for a diameter class within the range of diameter classes for which yields are available, a card must be included for that diameter class even though the yields are zero.

1. Number of logs — the number of logs, by diameter class, that were used to determine the expected lumber yields.
2. Diameter class — the diameter class for which the expected yields are shown.
3. Lumber tally — this is the total lumber tally volume, by diameter class, for which expected lumber grade yields are shown.
4. Expected lumber grade yields — these are the expected yields in percent for up to 10 lumber grades plus special products for each diameter class. These yield percentages must be recorded for all lumber grades shown in the expected yields, even if the mill to be analyzed does not cut that lumber grade. For example, the mill may not cut a sound wormy grade when producing oak lumber. But, if the expected yields show a yield for this lumber grade, it must be recorded. The yield percentages are recorded to one decimal place. But the decimal point is not recorded. A value of 14.7 percent is recorded as 147.

Component 11 - chip yield card

This card requires the following information. Figure 6 (Chip Yield Data Sheet) shows how this information is recorded.

1. Chip yield code — this indicates how the chip yields are taken. The codes are:
   2. Chip yields are desired by log grade.
   1. Chip yields are combined for all log grades.

0. Chip yields are not desired.

2. Chip yield information — this includes the chip yield for up to five log grades or for all grades combined. If chip yields are combined, the chip yield information is entered in the grade 1 section. The chip yield information consists of the following values, by log grade.
   a. Chip yield in tons. This is the total green chip weight from a group of study logs.
   b. Lower sawing order number. This is the lowest sawing order number of the group of logs from which the chip weight was obtained. The sawing order number mentioned here is discussed under component 12 (Fig. 7).
   c. Upper sawing order number. This is the highest sawing order number of the group of logs from which the chip weight was obtained.

Component 12 - log information card

This card contains the following information for each study log. Figure 7 (Sawlog Data Sheet) shows how the information is recorded.

1. Log number — the identification number or the color code that is painted on each study log.
2. Species identification — these initials identify the species of the sawlog.
3. Log grade — the grade of the sawlog.
4. Small end diameter — the scaling diameter of the sawlog in inches.
5. Large end diameter — the diameter at the large end of the log in inches.
6. Log length — the length of the sawlog rounded down to the whole foot (nominal length) or rounded to the nearest 0.1 of a foot depending on what was specified in component 4. If this measurement is taken to the nearest 0.1 of a foot, the decimal point is not recorded. A length of 10.4 feet is recorded as 104.
7. Log defect — the volume defect in the log recorded in whole board feet.
8. Species name — the species name is entered only for the first log in the grade.
9. Species code number — this code is for species identification. We recommend that you use the code numbers given in the Northeastern Forest Survey Field Manual,[4] which lists them in the appendix.
10. Sawing time — the sawing time for each log recorded in minutes and hundredths of minutes. A time of 4.69 minutes is recorded as 469. These times, along with log number and sawing order number, are recorded on the Sawing Time Data Sheet (Fig. 8) and then transferred by log number to the Sawlog Data Sheet (Fig. 7).
11. Mill type — this is the same identification code used for component 3. Although this code is not necessary, it should be included. The analyst may want to use the sawlog data for purposes other than the SOLVE II analysis. In that case, the code will be useful.
12. Sawing order number — this number indicates the order in which the logs are sawed. These numbers and corresponding log numbers are recorded on the Sawing Time Data Sheet (Fig. 8) and then transferred by log number to the Sawlog Data Sheet (Fig. 7). The logs are not usually processed in the same order as they are numbered during the log selection process. Therefore, the log number and the sawing order number will not usually be the same.

Component 13 - lumber yield cards

The lumber yield information should be entered on the Lumber Tally Sheet (Fig. 9) in the mill and then transferred to the Lumber Yield Data Sheet (Fig. 10) in the office. This procedure is necessary to get the yield data in the form required for the computer program.

Before recording the lumber yields on the tally sheet, the recorder must first write in the lumber grade titles under the grade numbers. These titles and their respective numbers must be the same as those used in component 5. For example, if FAS was used for grade 1 in component 5, it must also be used for grade 1 on the Lumber Tally Sheet.

As the first study log is sawed, the number 1 is written under sawing order number on the Lumber Tally Sheet. If a color code is used, the color can also be written here. Then the log identification number is written in the log number column.

[4] U.S. Forest Service. [n.d.] Northeastern forest survey field manual. U.S. Dep. Agric. For. Serv., Northeast. For. Exp. Stn., Upper Darby, Pa. 96 p.

When the lumber from the log gets to the green chain, the boards are scaled and graded. As this is done, the surface measure for each piece is written in the block corresponding to the thickness and grade of the lumber. For example, in Figure 9, log 75 had five 4/4-inch boards; one FAS piece with a surface measure of 7 square feet, two 3A Common pieces with surface measures of 5 square feet and 9 square feet respectively, and two 3B Common pieces with surface measures of 5 square feet each.

When special products (ties, timbers, cants, etc.) from the log get to the green chain, they are scaled and the surface measures are recorded under grade 11 by thickness. For example, in Figure 9, log 75 had a 4-inch cant with a surface measure of 5 square feet.

Boards and special products with thicknesses greater than those shown on the Lumber Tally Sheet can be handled by adjusting the surface measure. For example, the yield for a 16/4-nch piece of lumber can be recorded as an 8/4-inch piece by doubling the surface measure. This is also true for a 16-inch timber. It can be recorded as an 8-inch timber by doubling the surface measure.

After the yields have been recorded on the tally sheet, they must be transferred to the Lumber Yield Data Sheet (Fig. 10). To illustrate this procedure, the sample data shown in Figure 9 have been transferred to Figure 10. Each line on the Lumber Yield Data Sheet represents a lumber yield card for component 13. These cards require the following information:

1. Log number — the log identification number.
2. Species identification — these initials specify the log species. They must correspond to the initials used on the Log Information Card.
3. Lumber thickness — this is the nominal lumber thickness in 1/4 inches for lumber grades 1 through 10, and in inches for grade 11 (special products).
4. Lumber yields — these are the yields recorded in surface measure for each lumber thickness and grade number.

Component 14 - end card

The end card consists of the value of 99 entered in columns 14 and 15. This card is put at the end of the data for each species.

III. COMPUTER CARD PREPARATION AND USE

Punching cards

Once you have collected and checked the data, they must be transferred to computer cards. You may have the cards punched directly from the data sheets or transfer the information to computer spread sheets first, and then have the cards punched. In either case, the card column numbers are given on the data sheets to show the location of each item on the cards.

If the cards are to be punched by a person who is not familiar with the SOLVE II format, you should transfer the data to spread sheets first. This will help eliminate punching errors. Whether the cards are punched from the data sheets or from spread sheets, they should be checked carefully for mispunched data. You should be especially watchful for cards with all of the data shifted a space or two to the right or left of the correct columns.

Arranging cards

After the cards have been punched and checked for accuracy, they must be arranged by components as shown in Figure 1. Note that components 4 through 14 are repeated for each species in the analysis.

When expected lumber yields are used, components 9 and 10 are repeated for each log grade that has been specified on component 7. If expected yields are not used, this fact is noted on component 7, and components 8 through 10 are omitted.

Components 12 and 13 must be repeated for each log within the species. In other words, for a given log, the lumber yield cards must follow the log information card.

Computer run

Once the cards have been arranged in order by components, they are ready for computer processing. This requires a computer with a storage capacity of at least 520K. The computer does not need disk, tape, or plotting capabilities. The program does not use this equipment. However, the computer must provide output that is 132 characters wide.

If you are not familiar with the control cards required by your computer, you should get assistance from computer center personnel to help

run the program the first time. These people can also assist you with any other minor problems that may result from the differences in the compilers used by different computer centers.

Figure 1.—Arrangement of cards for SOLVE II program.

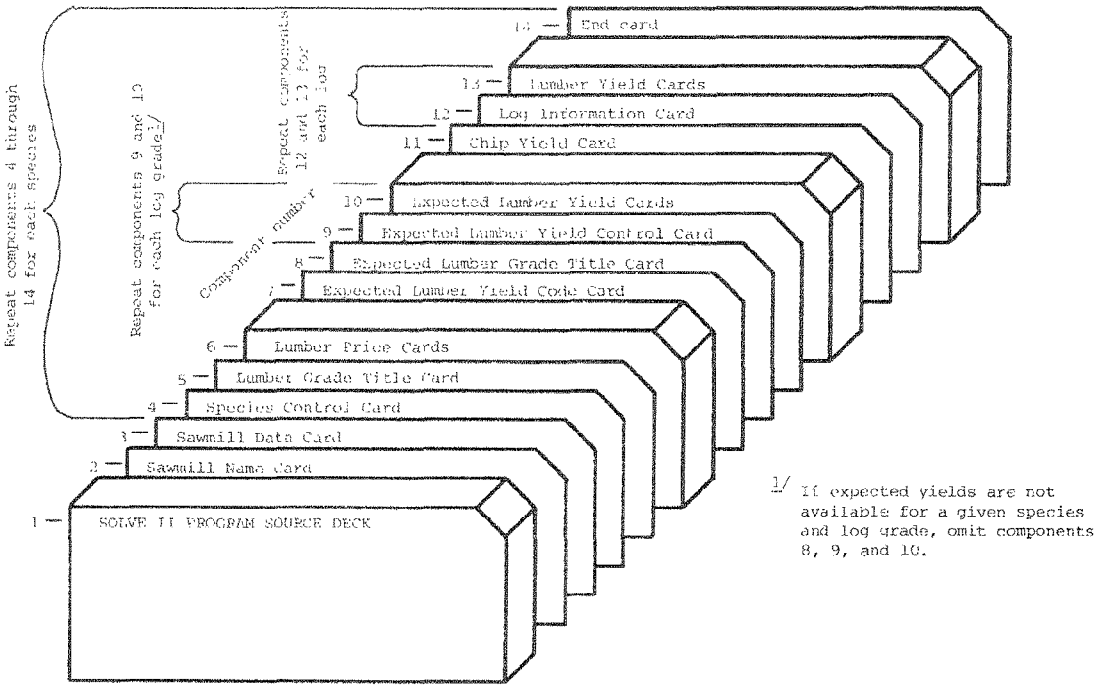

Figure 2.—Dot tally of study logs by diameter and even-length classes.

Species: *Hard Maple*

Grade: *3*

Diameter (inches)	Log length (feet) 8	10	12	14	16
8	8	9	8	5	1
9	5	7	12	6	
10	3		4	3	2
11		2			
12					
13					
14	1				
15			1	1	

Figure 3.—Basic mill data sheet.

Comp. No. 2 - Sawmill Name Card (One Card)

1. Sawmill name (Col. 1-Col. 28) SAWDUST LUMBER CO.
2. Number of species (Col. 33) 1

Comp. No. 3 - Sawmill Data Card (One Card)

1. Month of analysis (Col. 2 and Col. 3) 3
2. Day of analysis (Col. 5 and Col. 6) 16
3. Year of analysis (Col. 8 and Col. 9) 76
4. Operating cost/minute (Col. 12-Col. 15) 1.73
5. Chip price/ton (Col. 17-Col. 21) 13.50
6. Mill type (Col. 26) 2
7. Profit margin in percent (Col. 32 and Col. 33) 10
8. Risk margin in percent (Col. 36 and Col. 37) 0
9. Broker fee in percent (Col. 40 and Col. 41) 5
10. Cash discount in percent (Col. 44 and Col. 45) 2
11. Average productive headsaw time/day (Col. 47-Col. 51) 8.00
12. Average number hours worked/day (Col. 53-Col. 57) 9.00
13. Log rule code (Col. 60) 2

Figure 4.—Basic species data sheet.

Comp. No. 4 - Species Control Card (One Card)

1. Species name (Col. 1-Col. 20) HARD MAPLE
2. Log grading system code (Col. 25) 1
3. Sawing time regression code (Col. 30) 0
4. Output by log grade code (Col. 35) 0
5. Log length code (Col. 40) 1
6. Lumber degrade factor (Col. 43-Col. 45) 100

Comp. No. 5 - Lumber Grade Title Card (One Card)

Grade Number	1	2	3	4	5	6
Columns	(2-5)	(7-10)	(12-15)	(17-20)	(22-25)	(27-30)
Titles	FAS	F1F	1C	3A	3B	

Grade Number	7	8	9	10	11
Columns	(32-35)	(37-40)	(42-45)	(47-50)	(52-55)
Titles					PROD

Comp. No. 6 - Lumber Price Cards (Seven Cards)

1. Species identification (Col. 1 and Col. 2 on each card)
2. Lumber price per MBF by lumber and thickness:

Card	Spec. Id.	Thick-ness	Lumber Grade Numbers 1	2	3	4	5	6	7	8	9	10	11
	Col. (1-2)	Col. 4	Columns (7-9)	(11-13)	(15-17)	(19-21)	(23-25)	(27-29)	(31-33)	(35-37)	(39-41)	(43-45)	(47-49)
1	HM	2											
2	HM	3											
3	HM	4	340	330	250	145	130						125
4	HM	5	350	340	260	155	140						125
5	HM	6	365	355	280	160	145						125
6	HM	7											125
7	HM	8	395	385	295	165	145						125

Figure 5.—Expected lumber yield data sheet.

Comp. No. 7 - Expected Yield Code Card (One Card)

Log Grades	1	2	3	4	5
Columns	(5)	(10)	(15)	(20)	(25)
Code	1	1	1	0	0

Comp. No. 8 - Expected Lumber Grade Title Card (One Card)

Grade Number	1	2	3	4	5	6
Columns	(2-5)	(7-10)	(12-15)	(17-20)	(22-25)	(27-30)
Titles	FAS	1F	SEL	1C	2C	3A

Grade Number	7	8	9	10	11
Columns	(32-35)	(37-40)	(42-45)	(47-50)	(52-55)
Titles	3B				TMBR

Comp. No. 9 - Expected Yield Control Card (One Card)

1. Species name (Col. 1-Col. 12) HARD MAPLE
2. Log grade (Col. 14-Col. 20) GRADE 1
3. Lower log diameter limit (Col. 24-Col. 25) 13
4. Upper log diameter limit (Col. 29-Col.30) 24

Comp. No. 10 - Expected Yield Cards (One for each Diameter Class)

Logs	Diam. Class	Lumber Tally	Lumber Grade Numbers										
			1	2	3	4	5	6	7	8	9	10	11
			Columns										
Col. (5-7)	Col. (9-10)	Col. (25-29)	(31-33)	(35-37)	(39-41)	(43-45)	(47-49)	(51-53)	(55-57)	(59-61)	(63-65)	(67-69)	(71-73)
56	13	5222	147	132	41	267	142	105	166	---	---	---	---
47	14	5329	232	127	44	247	151	70	129	---	---	---	---
54	15	6719	242	117	35	237	141	85	143	---	---	---	---
66	16	8658	195	115	31	275	170	69	145	---	---	---	---
74	17	11155	209	130	34	281	166	51	121	---	---	---	---
56	18	9656	243	132	31	250	157	60	127	---	---	---	---
34	19	6452	214	117	26	281	173	65	124	---	---	---	---
47	20	10409	266	131	27	258	156	71	91	---	---	---	---
22	21	5025	277	139	28	268	144	71	73	---	---	---	---
14	22	3831	209	81	22	216	122	72	90	---	---	---	---
8	23	2124	257	125	28	242	105	68	75	---	---	---	---
1	24	191	528	52	16	236	89	63	16	---	---	---	---

Figure 6.—Chip yield data sheet.

Comp. No. 11 - Chip Yield Card (One Card)

Chip Yield Code (Col. 1) ____ 1

Log Grade 1
- a. Chip yield in tons (Col. 3-Col. 8) ____ 8.58
- b. Lower sawing order number (Col. 10-Col. 12) ____ 1
- c. Upper sawing order number (Col. 14-Col. 16) ____ 15

Log Grade 2
- a. Chip yield in tons (Col. 18-Col. 23) ____ 0.00
- b. Lower sawing order number (Col. 25-Col. 27) ____ 0
- c. Upper sawing order number (Col. 29-Col. 31) ____ 0

Log Grade 3
- a. Chip yield in tons (Col. 33-Col. 38) ____ 0.00
- b. Lower sawing order number (Col. 40-Col. 42) ____ 0
- c. Upper sawing order number (Col. 44-Col. 46) ____ 0

Log Grade 4
- a. Chip yield in tons (Col. 48-Col. 53) ____ 0.00
- b. Lower sawing order number (Col. 55-Col. 57) ____ 0
- c. Upper sawing order number (Col. 59-Col. 61) ____ 0

Log Grade 5
- a. Chip yield in tons (Col. 63-Col. 68) ____ 0.00
- b. Lower sawing order number (Col. 70-Col. 72) ____ 0
- c. Upper sawing order number (Col. 74-Col. 76) ____ 0

Figure 7.—Sawlog data sheet.

Comp. No. 12 - Log Information Card (One Card For Each Log)

Log Number	Species Ident.	Log Grade	Small End Diameter	Large End Diameter	Log Length	Log Defect*	Species Name (For first log only in each log grade)	Species Code Number	Sawing Time	Mill Type	Sawing* Order Number
Col. (2-5)	Col. (7-9)	Col. (15)	Col. (19-20)	Col. (24-25)	Col. (28-30)	Col. (34-35)	Col. (37-51)	Col. (57-60)	Col. (62-65)	Col. (70)	Col. (77-80)
1	HM	1	16	21	103	0	HARD MAPLE	318	469	2	101
2	HM	3	21	24	104	28		318	423	2	94
3	HM	3	10	10	82	0		318	140	2	95
4	HM	2	19	20	93	20		318	240	2	88

* Transferred from Sawing Time Data Sheet

Figure 8.—Sawing time data sheet.

Log Sawing Order Number	Log Number	Sawing* Time		Log Sawing Order Number	Log Number	Sawing* Time
1	75	5.42				
2	30	2.33				
3	31	2.30				
4	60	3.13				
5	11	1.95				
6	24	3.17				
7	27	2.03				
8	23	3.05				
9	32	3.65				
10	56	4.47				

* Sawing times are recorded in minutes and hundredth of minutes. When these times are transferred to Sawlog Data Sheet, omit the decimal points.

Figure 9.—Lumber tally sheet.

Sawing Order Number	Log Number	Thickness (inches)	Lumber Grade (Numbers and Titles)										Thickness (inches)	Spec. Prod.
			1	2	3	4	5	6	7	8	9	10		11
			FAS	F1F	1C	2A	3B							PROD
1	75	2/4											2	
		3/4											3	
		4/4	7			5 9	5 5						4	5
		5/4											5	
		6/4											6	
		7/4											7	
		8/4	5		5	5							8	
2	30	2/4											2	
		3/4											3	
		4/4	5 9 9	3 4		3							4	
		5/4											5	
		6/4											6	4
		7/4											7	
		8/4	7 4 4 6		4								8	
3	31	2/4											2	
		3/4											3	
		4/4		7			4 4 4 5						4	
		5/4											5	
		6/4											6	4
		7/4											7	
		8/4											8	
4	60	2/4											2	
		3/4											3	
		4/4		8		3							4	
		5/4											5	
		6/4											6	
		7/4											7	6
		8/4	6		4	4							8	

Figure 10.—Lumber yield data sheet.

Comp. No. 13 - Lumber Yield Cards (One for Each Lumber Thickness)

Log Number	Species Ident.	Thickness	Grade	Surface Measure	Grade	Surface Measure	Grade	Surface Measure	Grade	Surface Measure	Grade	Surface Measure	Grade	Surface Measure
Col. (2-5)	Col. (7-9)	Col. (15)	Col. (9-20) (23-25)		Col. (29-30) (33-35)		Col. (39-40) (43-45)		Col. (49-50) (53-55)		Col. (59-60) (63-65)		Col. (69-70) (73-75)	
75	HM	4	1	7	4	14	5	10	11	5				
75	HM	8	1	5	3	5	4	5						
30	HM	4	1	23	2	7	4	3						
30	HM	6	11	4										
30	HM	8	1	21	3	4								
31	HM	4	2	7	5	17								
31	HM	6	11	4										
60	HM	4	2	8	4	3								
60	HM	7	11	6										
60	HM	8	1	6	3	4	4	4						

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—703-112-36

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

- Beltsville, Maryland.
- Berea, Kentucky, in cooperation with Berea College.
- 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.
- Kingston, Pennsylvania.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Pennington, New Jersey.
- Princeton, West Virginia.
- Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.
- Warren, Pennsylvania.