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Reduce Dimension Costs by Using WALNUT

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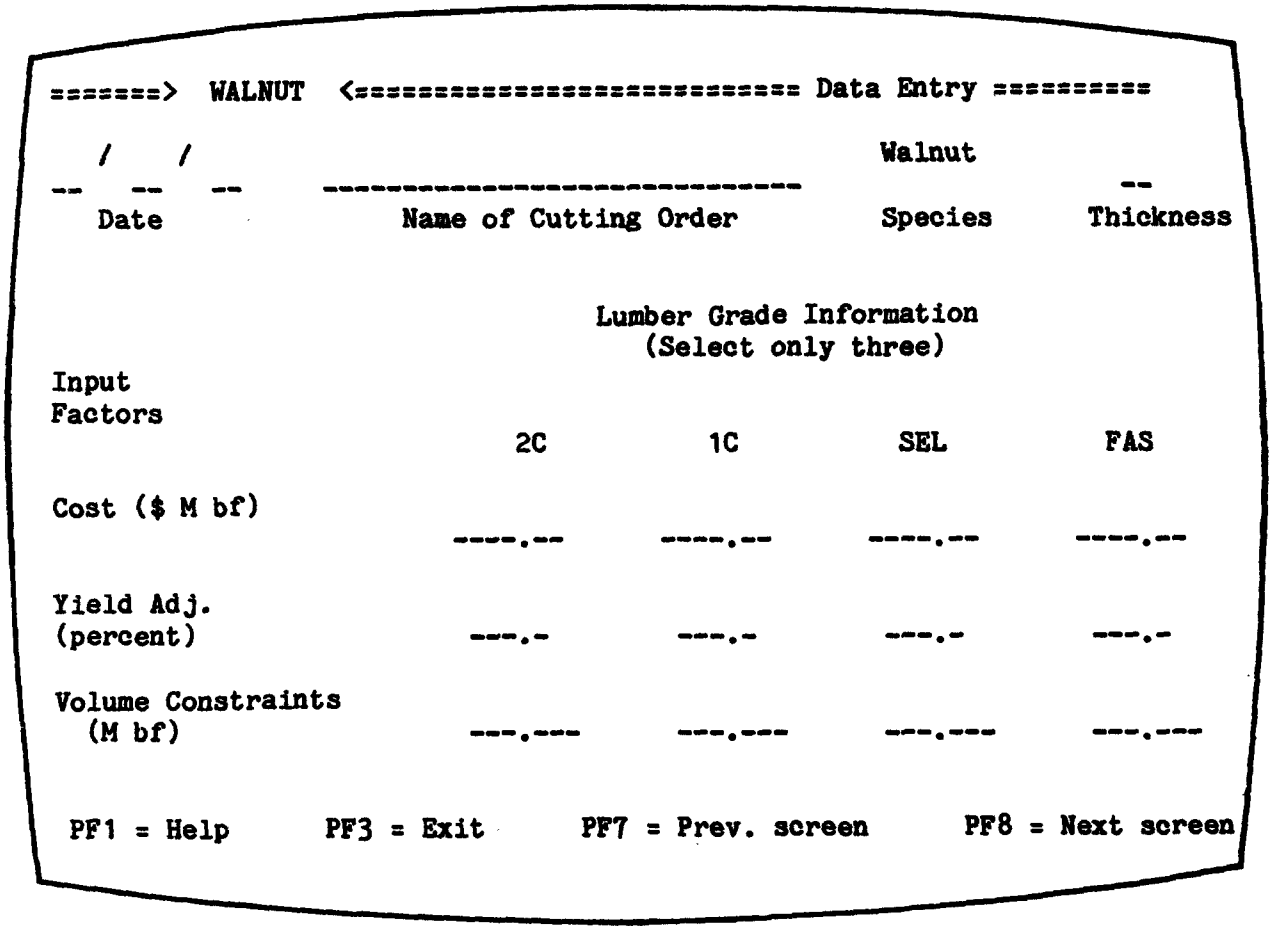

The Author

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Abstract

A computer program called WALNUT is described that determines the least-cost combination of lumber grades required to produce a given cutting order of walnut furniture dimension parts. If the least-cost mix is not available, WALNUT can be used to determine the next best alternative. The steps involved in using the program are described.

American black walnut has long been a favorite species for furniture in this country. However, increasing demand for fine furniture and decreasing supplies of high-quality walnut lumber have made prices skyrocket. As a result, furniture dimension manufacturers making walnut parts have been caught in the middle of a cost-price squeeze.

To help alleviate this situation, a computer program called WALNUT has been developed that determines the least-cost mix of walnut lumber grades required to produce a given dimension cutting order. Through linear programing techniques, WALNUT correlates the cost associated with each grade of lumber with the predicted yields of each cutting size obtainable from that grade to arrive at the combination with the lowest total cost. The program is easy to use and can be quickly adapted to fit most furniture rough mills and dimension manufacturing operations.

Data Entry

Input to the WALNUT program is accomplished using the Data Entry screen shown in Figure 1. For future reference, the date, name or model number of the cutting order, and the thickness of the lumber required are entered. The input factors used by the program include the cost per thousand board feet (M bf) associated with each grade of walnut to be considered in the possible least-cost mix, any adjustments desired in the predicted yields for each grade, and any volume constraints to be placed on the grades.

The cost of each grade should represent the sum of all costs associated with that grade through the rough mill. Cost items to be included are at the discretion of the user but could include those for lumber purchase, delivery, drying and handling, rough-mill cutup, inventory, and overhead.

The yield adjustment factor can be used to adapt the basic yields for admissible defects, heavy thicknesses of lumber, or general rough-mill efficiency. The yield values used in WALNUT are derived from nomographs published in USDA Forest Service Research Paper FPL-162 entitled "Dimension Yields From Black Walnut Lumber." The actual numerical yield values and the width adjustments for Firsts and Seconds (FAS), Selects (SEL), No. 1 Common (1C), and No. 2 Common (2C) are extrapolated from Tables 3-10 (Appendix). The yields for each length within a grade are based on the longest length obtained from that grade and are expressed as the net board feet of parts available per M bf of rough lumber input. Consequently, you can place a decimal after the second digit and consider them percentage yields. Yields are for random-width cuttings of 1 inch or wider. Yields for specific widths are obtained by subtracting the appropriate width adjustment from the random-width yields.

Although the WALNUT program can accommodate lengths from 10 to 96 inches and specified widths up to 5½ inches, the length limitations differ for individual grades of walnut lumber. As shown in the yield tables, the longest length available is 96 inches from FAS, 90 inches from SEL, 80 inches from 1C, and 70 inches from 2C.

The volume constraints factor is used to limit the amount of a grade being considered. The resulting evaluation may or may not use all of the grade in limited supply, but in no case will the least-cost grade mix contain more of that grade than the volume allowed. This feature of the program is generally used in determining next best alternatives.

```
=======>  WALNUT  <============================ Data Entry ==========

   /   /                                              Walnut
--  --  --     ------------------------------                    --
   Date              Name of Cutting Order            Species      Thickness

                                    Lumber Grade Information
                                      (Select only three)
Input
Factors
                                 2C          1C          SEL          FAS

Cost ($ M bf)
                               ----.--     ----.--     ----.--      ----.--

Yield Adj.
(percent)                       ---.-       ---.-       ---.-        ---.-

Volume Constraints
  (M bf)                      ---.---     ---.---     ---.---      ---.---

 PF1 = Help      PF3 = Exit      PF7 = Prev. screen      PF8 = Next screen
```

Figure 1.—Data Entry screen.

Cutting Order

Once the grades and costs have been established, the individual sizes of pieces to be obtained are entered using the Cutting Order screen (Figs. 2-3). Each size of cutting is entered by length, width, type, and number required. WALNUT can accommodate 50 sizes of cuttings or panels. An R is entered for panels that will be glued up from random-width pieces. An S is entered when each part is to have a specified width.

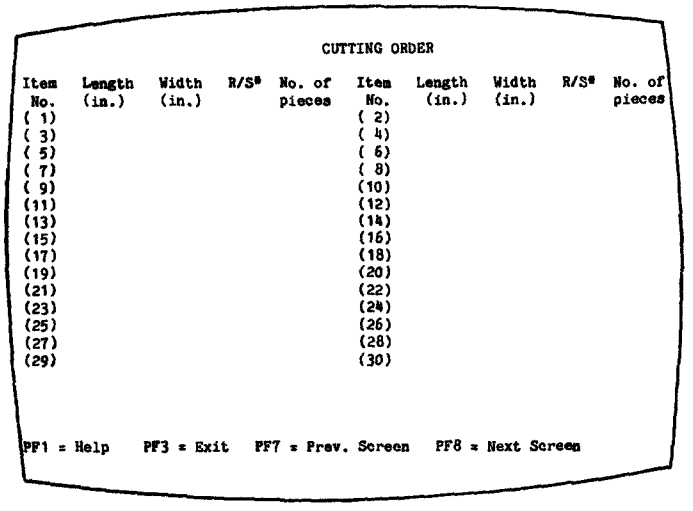


Figure 2.—Cutting order (screen 1).

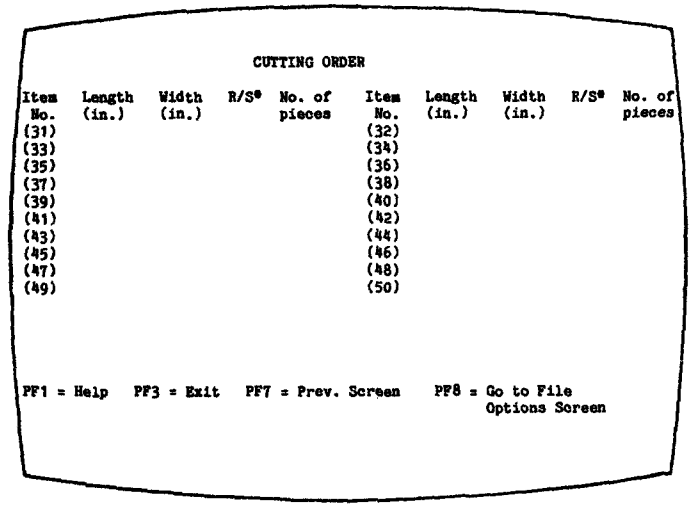


Figure 3.—Cutting order (screen 2).

WALNUT Printout

The WALNUT printout consists of four sections: (1) the input information that was evaluated, (2) the least-cost grade mix, (3) the range and sensitivity analysis, and (4) the cutting instructions to obtain the desired cuttings.

Input Information

The first section is to be retained for future reference. It provides a record of the information that was on the Data Entry and the Cutting Order screens.

Least-Cost Grade Mix

The second section provides the least-cost grade mix solution (Table 1). For each grade of lumber, the printout shows the predicted lumber volume required, the grade's contribution to the total production cost, the net board feet of cuttings to be obtained from it, the percent yield, and the totals of these items for the entire cutting order.

For the costs and conditions we have specified, this solution represents the best that we can do. There is no other combination of grades and volumes that will result in a lower total cost.

Range and Sensitivity Analysis

The range and sensitivity analysis (Table 1) is the key to using WALNUT as a decisionmaking tool. It indicates how good our current least-cost grade mix is relative to the next best alternatives. As such, it also indicates how we might allocate our lumber when conditions are less than optimal.

The range and sensitivity analysis shows the range over which the input cost of each grade can move without changing the least-cost grade mix, assuming that the input cost of the other grades remains constant. By varying the input cost of one grade while holding the others constant, the program determines at what level of input cost there would be a change in how the grades are used to obtain the cuttings required. The "associated gross volumes" column lists the volume of the grade that would be used at that input cost.

In Table 1, it can be seen that if the input cost of 1C dropped by $1.66 per M bf to $1,108.34, the volume of 1C used in the alternative least-cost mix would increase by 45 percent to 5.500 M bf. Since the alternative mix must have the same total cost as our current least-cost mix, it stands to reason that if more 1C lumber is used in the solution, it must use less of at least one of the other grades. By examining the associated gross volumes shown for the other grades, you can determine that at the lower input cost for 1C, no FAS would be used and the amount of 2C would be reduced to 13.974 M bf. Proof can be obtained by comparing the total cost of our current grade mix with that of the alternative mix for the input cost conditions in this example. Total costs would be:

	FAS	1C	2C	Total
Current	($1,792 × 0.656) +	($1,108.34 × 3.798) +	($575 × 15.210)	=$14,131
Alternative	($1,792 × 0) +	($1,108.34 × 5.500) +	($575 × 13.974)	=$14,131

With this knowledge, the manager could choose the alternative grade mix under current cost conditions, eliminating the need for FAS lumber. The alternative mix would increase the total cost only by about $3 ($14,140 compared to $14,137, as shown in Table 1).

For a more complete discussion of the interpretation of the range and sensitivity analysis and how it can be used as a decisionmaking tool, see USDA Forest Service Research Paper NE-563 entitled "OPTIGRAMI: Optimum Lumber Grade Mix Program for Hardwood Dimension Parts."

Cutting Instructions

The last section of the WALNUT printout is the cutting instructions (Table 2) for obtaining the required furniture cuttings from the proposed least-cost mix. This section is normally given to the rough-mill foreman for use in assigning lengths to specific saw operators.

Table 1.—Least-cost grade mix solution (Nov. 30, 1985: china cabinet No. 7335—walnut)

Selected grade	Input Cost/ M bf	Gross volume	Total production cost	Board feet of cuttings	Percent yield
	Dollars	*M bf*	*Dollars*	*Number*	
No. 2 Common	575	15,210	8,746	7,141.8	47.0
No. 1 Common	1,110	3,798	4,216	2,267.2	59.7
First and Seconds	1,792	656	1,174	483.5	73.7
Total		19,664	14,137	9,892.5	50.3

RANGE AND SENSITIVITY ANALYSIS

Selected grade		Input cost and levels/M bf	Associated gross volumes
		Dollars	*M bf*
No. 2 Common	Upper	577.28	13,974
		575.00	15,210
	Lower	571.78	15,438
No. 1 Common	Upper	1,112.36	3,487
		1,110.00	3,798
	Lower	1,108.34	5,500
First and Seconds	Upper	1,796.31	0
		1,792.00	656
	Lower	1,785.88	775

Table 2.—Optimum solution cutting information (Nov. 30, 1985: china cabinet No. 7335—walnut)

Gross volume	Cutting size		Type of cutting[a]	Cuttings	Net board feet	Board feet shorts
	Length	Width				
M bf	------- *Inches* ------			---------- *Number* ----------		
			NO. 2 COMMON[b]			
15,210	36.750	22.000	R	142	797.3	517.1
	22.750	22.000	R	86	298.9	
	15.750	22.000	R	1,330	3,200.3	
	30.875	2.250	S	622	300.1	
	24.375	2.250	S	3,052	1,162.4	
	16.500	2.250	S	4,422	1,140.1	
	13.875	2.250	S	1,119	242.7	
			NO. 1 COMMON[b]			
3,798	73.375	2.250	S	346	396.7	87.4
	62.500	2.875	S	294	366.6	
	56.875	2.250	S	225	200.0	
	37.875	2.875	S	685	518.1	
	24.375	2.250	S	1,412	537.7	
	16.500	2.250	S	759	195.7	
	13.875	2.250	S	242	52.4	
			FIRSTS AND SECONDS[b]			
656	62.500	2.875	S	266	332.1	8.5
	37.875	2.875	S	109	82.3	
	16.500	2.250	S	249	64.1	
	13.875	2.250	S	23	4.9	
19,664				15,383	9,892.5	613.0

[a]R = random; S = specified.
[b]4/4 lumber thickness.

It provides the input volume for each grade according to the least-cost mix, the cutting sizes that are to be obtained from each grade, and the number of pieces that are expected from that volume of lumber.

The computer evaluates all combinations of cutting requirements and yield per grade to determine the least-cost combination. The results are not always according to tradition. For example, in the cutting instructions shown (Table 2), the longest length in the cutting order (73.375 inches) is obtained exclusively from 1C and not FAS. Instead, FAS is used to supplement the requirements for the 62.5, 37.875, 16.5, and 13.875 cutting lengths. However, this combination of lengths results in a 73.7-percent yield of cuttings from FAS (Table 1).

The cutting instructions also include the value "board feet shorts." This represents the net board feet of unused volume that would be available as 10-inch-long, random-width cuttings. As such, it provides an indication of how well the raw material is being utilized.

In addition to information on each grade, there is a summary for the entire cutting order. Included are the total gross volume of lumber required, the total net board feet of cuttings to be obtained, the total board feet of shorts anticipated, and the total number of pieces required.

WALNUT as a Decisionmaking Tool

Because walnut lumber is an expensive commodity, relatively small adjustments in the grade composition of the lumber going to the rough mill can have significant effects on the cost of the dimension produced.

WALNUT can be a valuable tool in determining the best, or least-cost, combination of grades to use for specific cutting orders. If an adequate quantity of a specific grade recommended in the least-cost mix is not available, WALNUT can be rerun using the volume constraints feature to determine the next best alternative.

The upper and lower input cost levels shown in the range and sensitivity analysis are an indication of the relative value of each grade in relation to the value of the other grades when used in a particular cutting order. Consequently, decisions regarding the allocation of lumber to several cutting orders can be made.

For instance, assume that in scheduling the daily cutting orders to be processed by the rough mill, there was not enough 1C available to satisfy the least-cost grade mix for two separate cutting orders. By comparing the upper input cost level for 1C lumber in each cutting order, the manager could elect to allocate the available 1C to the cutting order with the highest upper limit because that is where 1C would have its highest value use. The remaining 1C would be used in the other cutting order, which would be reevaluated using the volume constraints feature in WALNUT. By allocating the available 1C lumber in this manner, the total cost of processing the pair of cutting orders would be at a minimum. More than two orders would be handled in the same way, always giving priority to the cutting order providing the highest valued use of a particular grade.
WALNUT, and its companion programs OPTIGRAMI and YELLOPOP ("Producing Yellow-Poplar Furniture Dimension at Minimum Cost Using YELLOPOP," USDA Forest Service Research Paper NE–592, in press), can provide valuable insight into numerous other management decisions besides specific least-cost grade mixes. OPTIGRAMI is used to evaluate cutting orders from all species graded by the standard National Hardwood Lumber Association rules and YELLOPOP is used for yellow-poplar. As management tools, they can help in making decisions regarding the grades of lumber that should be purchased, scheduling of lumber to be dried, improving rough-mill efficiency, or improving yields through changes in design. Creative managers will find additional applications.

Using WALNUT

WALNUT is designed for use on any IBM mainframe computer with a mathematical programing system (MPS) in its program library. The program can be accessed through an on-site computer or through a remote terminal.

Remote Terminal

For users wishing to use a remote terminal, WALNUT has been placed on the Computerized Management Network (CMN)—a national time-sharing computer service managed by the Virginia Cooperative Extension Service. Access to CMN can be made with any ASCII terminal and a modem, or with a microcomputer with a communications program.

CMN is accessed through normal long distance telephone lines. To LOG ON, you will need to obtain a CMN user identification number (userid) and password by contacting:

> Virginia Polytechnic Institute & State University
> Virginia Cooperative Extension Service
> Extension Computing Resources
> Plaza I, Building D
> Blacksburg, VA 24061
> 703-961-5184

There is no initial fee or hookup charge for CMN, but there is a small monthly userid ownership charge.

To use the program, simply dial the computer telephone number and LOG ON with your CMN userid and password. The computer will then ask you what program you would like. Enter "WALNUT." The Main Menu (Fig. 4) will ask what you would like to do. By pressing one of the four function (PF) keys, you can request a file for editing or analysis, determine if a submitted analysis has been returned to your userid, get the HELP file, or exit the program. If you wish to make a WALNUT analysis, press the PF4 key. A File Specification screen will ask you to enter a file name (Fig. 5). The file names that you have previously run also will be listed. To enter a file name, enter a name of from one to eight characters in the file name field and press the ENTER key, or position the cursor at the name of one of your existing files and press ENTER (this copies the name at the cursor to the file name field at the top of the screen); press ENTER again to validate the name you have selected. A message will appear at the bottom of the screen indicating that the requested file is an old file.

Now that you have selected your file, press the PF8 key to proceed to the File Options screen (Fig. 6). Press a PF key to select whether you want to edit the select file (PF4), submit the file for processing (PF5), or specify your job priority (PF6). Since we are interested in making an analysis, we would press PF4 to proceed to the Data Entry screen (Fig. 1). You can move the cursor with the cursor controls or skip from field to field with the TAB key.

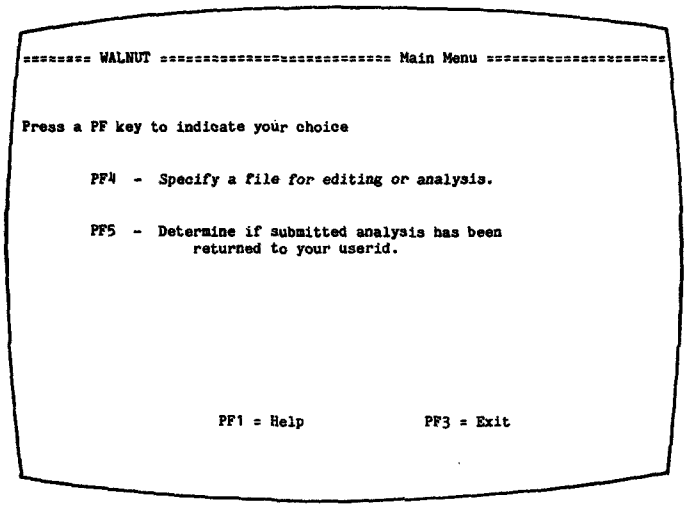


Figure 4.—Main Menu screen.

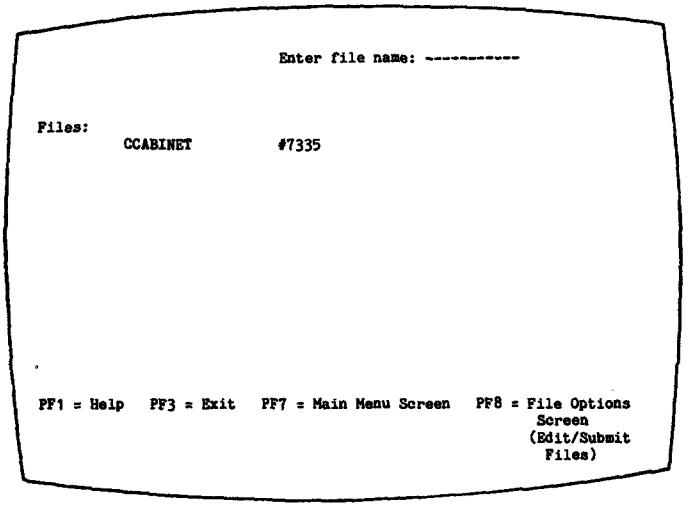


Figure 5.—File Specification screen.

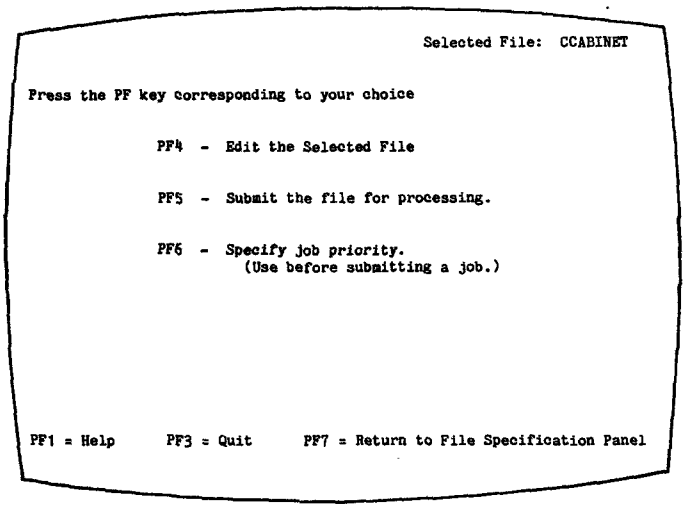


Figure 6.—File Options screen.

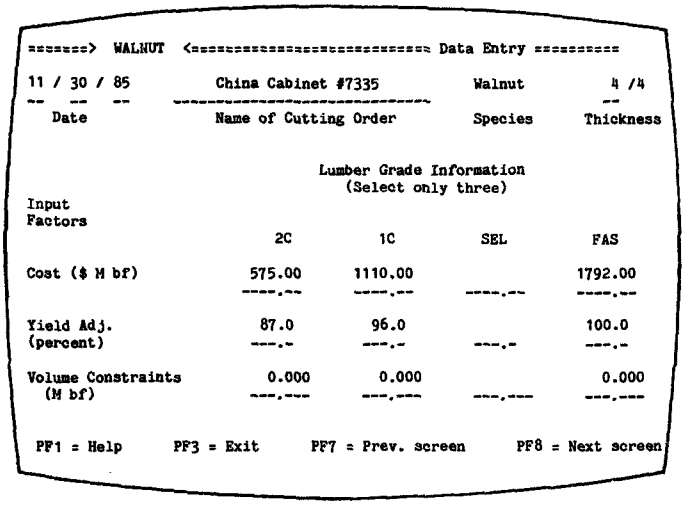
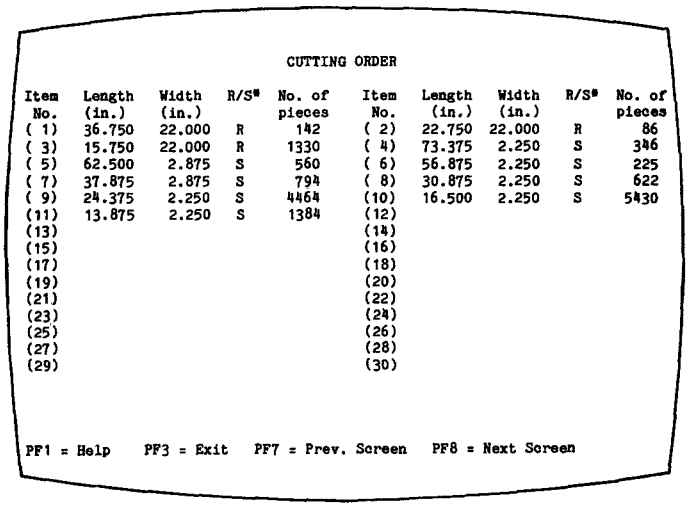


Figure 7.—Completed Data Entry screen.

On the completed Data Entry screen (Fig. 7), we have specified 4/4 thickness and the lumber grades of 2C, 1C, and FAS. The input costs of $575, $1,110, and $1,792 reflect estimates of the total of costs for each grade through the rough mill. The 87– and 96–percent yield adjustments for 2C and 1C are for demonstration purposes only. Since no volume constraints were used, the program assumes that there are unlimited volumes available for each grade. We would now press PF8 to move to the Cutting Order screens (Figs. 8–9). Part sizes do not need to be entered in a particular order, such as from longest to shortest.

Pressing the PF8 key takes us to screen 2 of the cutting order (Fig. 3) and pressing PF8 again takes us to the File Options screen (Fig. 6). By pressing PF6, we can specify our job priority (Fig. 9). Five levels of priority can be selected, from idle (least expensive) to urgent (most expensive). If no selection is made, the program is set to run on idle priority. Assuming that we are satisfied with our priority, we press PF5 to submit our file for processing. We will receive a message at the bottom indicating "WALNUT job submitted. Check for results after 10 minutes."

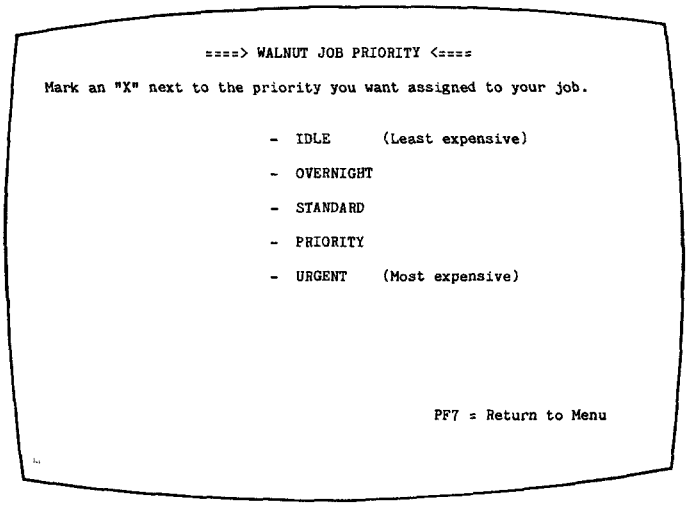


CUTTING ORDER

Item No.	Length (in.)	Width (in.)	R/S*	No. of pieces	Item No.	Length (in.)	Width (in.)	R/S*	No. of pieces
(1)	36.750	22.000	R	142	(2)	22.750	22.000	R	86
(3)	15.750	22.000	R	1330	(4)	73.375	2.250	S	346
(5)	62.500	2.875	S	560	(6)	56.875	2.250	S	225
(7)	37.875	2.875	S	794	(8)	30.875	2.250	S	622
(9)	24.375	2.250	S	4464	(10)	16.500	2.250	S	5430
(11)	13.875	2.250	S	1384	(12)				
(13)					(14)				
(15)					(16)				
(17)					(18)				
(19)					(20)				
(21)					(22)				
(23)					(24)				
(25)					(26)				
(27)					(28)				
(29)					(30)				

PF1 = Help PF3 = Exit PF7 = Prev. Screen PF8 = Next Screen

Figure 8.—Completed cutting order (screen 1).



====> WALNUT JOB PRIORITY <====

Mark an "X" next to the priority you want assigned to your job.

- IDLE (Least expensive)
- OVERNIGHT
- STANDARD
- PRIORITY
- URGENT (Most expensive)

PF7 = Return to Menu

Figure 9.—WALNUT job priority.

We can now press PF4 to make changes in our file if we want to rerun it with different lumber input costs, yield adjustments, or volume constraints. If we want to enter another analysis, we press PF7 to return to the File Specification screen (Fig. 5).

To receive our WALNUT output, we return to the Main Menu (Fig. 4) and press the PF5 key to determine if our submitted analysis has been returned to our userid. If it has not, we will receive a message at the bottom of the screen saying "No WALNUT output has been returned. Try again later." When the analysis is completed, the output is returned to your "reader." To look at the output, press PF11. This makes the entire WALNUT output available to you. You can scroll forward or backward by using the PF8 and PF7 keys.

If you wish to keep the output, press the PF9 key to have it recorded onto your CMN disk space as a permanent record or to have it printed. If you have a printer attached to your terminal, you can have the results printed by using the command "TPRINT" followed by the file name that you used (Fig. 5). You can discard the output by pressing the PF2 key or have it printed at Virginia Polytechnic Institute and State University (VPI&SU) by pressing the PF4 key. VPI&SU will then send you the results. Pressing the PF3 key returns you to the Main Menu.

On every screen requiring the selection of an option or the input of data, the PF1 key has been labeled HELP. By pressing it, a help file will be displayed to explain each of the options available to you.

Mainframe

Users who have access to an IBM mainframe computer can obtain a free copy of our WALNUT program library by sending a blank tape to the Forestry Sciences Laboratory, P.O. Box 152, Princeton, West Virginia 24740. The library will be copied onto it and returned with documentation.

If the IBM mainframe does not have an MPS in its program library, it will be necessary to obtain it before WALNUT will function. An MPSX can be obtained from an IBM representative or an MPSIII can be obtained from KETRON, Inc., Management Science System Divisions, 1400 Wilson Boulevard, Arlington, Virginia 22209.

All features available on the CMN version also are available on the mainframe version and they are operated identically.

Summary

WALNUT can make a signifcant difference in the total cost of walnut dimension parts by selecting the most economical combination of grades and volumes required to produce a given cutting order. WALNUT and its companion programs, OPTIGRAMI and YELLOPOP, are decisionmaking tools designed to help furniture and dimension rough-mill managers. They are easy to use and are adaptable to individual plant situations.

The computer program described in this publication is available on request with the understanding that the

U.S. Department of Agriculture cannot assure its accuracy, completeness, reliability, or suitablity for any other purpose than that reported. The recipient may not assert any proprietary rights thereto nor represent it to anyone as other than a Government-produced computer program.

Appendix

Table 3.—Predicted yields of random-width cuttings from FAS grade walnut lumber (net board feet per M bf)

Length of subsequent cuttings (inches)	Length of longest cuttings									
	10	20	30	40	50	60	70	80	90	96
	Inches									
96										180
90									280	312
80								360	398	422
70							432	482	510	534
60						478	530	572	592	608
50					498	544	582	618	638	648
40				560	600	612	628	652	672	680
30			620	660	678	680	682	684	690	706
20		670	702	724	730	730	730	730	730	732
10	730	750	760	762	762	760	760	758	758	750

Table 4.—Reduction values for obtaining predicted yields for cuttings of specified widths from FAS grade walnut lumber (net board feet per M bf)

Width of cuttings (inches)	Length of cuttings									
	10	20	30	40	50	60	70	80	90	96
	Inches									
2	40	36	30	28	22	20	16	10	8	4
3	70	64	56	48	40	36	30	22	18	10
4	112	96	86	78	68	60	46	30	20	14
5	266	246	230	220	208	198	188	168	138	84
5-½	380	354	336	320	302	285	264	226	180	118

Table 5.—Predicted yields of random-width cuttings from SEL grade walnut lumber (net board feet per M bf)

Length of subsequent cuttings (inches)	Length of longest cuttings								
	10	20	30	40	50	60	70	80	90
	Inches								
90									144
80								194	226
70							256	306	336
60						316	380	414	432
50					380	436	468	490	504
40				442	502	526	542	556	562
30			518	574	590	602	608	610	612
20		596	638	652	660	662	660	662	664
10	672	690	702	708	708	706	704	702	702

Table 6.—Reduction values for obtaining predicted yields for cuttings of specified widths from SEL grade walnut lumber (net board feet per M bf)

Width of cuttings (inches)	Length of cuttings								
	10	20	30	40	50	60	70	80	90
	Inches								
2	46	38	32	26	20	16	10	6	3
3	100	80	70	60	48	40	32	26	18
4	202	178	160	140	130	120	104	80	56
5	380	356	326	296	264	230	192	152	106
5-½	470	436	398	362	324	284	238	186	126

Table 7.—Predicted yields of random-width cuttings from No. 1 Common walnut lumber (net board feet per M bf)

Length of subsequent cuttings (inches)	Length of longest cuttings							
	10	20	30	40	50	60	70	80
	Inches							
80								86
70							140	170
60						198	238	256
50					270	310	338	352
40				344	400	422	434	440
30			440	488	508	522	526	530
20		530	570	586	594	598	600	600
10	626	644	652	656	654	652	650	650

Table 8.—Reduction values for obtaining predicted yields for cuttings of specified widths from No. 1 Common walnut lumber (net board feet per M bf)

Width of cuttings (inches)	Length of cuttings							
	10	20	30	40	50	60	70	80
	Inches							
2	38	28	20	16	10	8	5	2
3	106	96	84	66	46	38	32	28
4	256	228	198	172	154	128	98	66
5	420	382	338	280	234	186	138	80
5-½	470	436	378	318	260	201	146	84

Table 9.—Predicted yields of random-width cuttings from No. 2 Common walnut lumber (net board feet per M bf)

Length of subsequent cuttings (inches)	Length of longest cuttings						
	10	20	30	40	50	60	70
	Inches						
70							50
60						80	100
50					138	162	174
40				220	254	270	276
30			308	358	378	386	386
20		428	464	476	480	482	482
10	528	546	556	556	550	546	546

Table 10.—Reduction values for obtaining predicted yields for cuttings of specified widths from No. 2 Common walnut lumber (net board feet per M bf)

Width of cuttings (inches)	Length of cuttings						
	10	20	30	40	50	60	70
	Inches						
2	58	40	30	26	18	14	10
3	170	146	118	92	70	50	30
4	300	268	218	170	118	78	40
5	406	358	292	218	132	84	46
5-½	448	398	318	228	141	88	50

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Martens, David G. **Reduce dimension costs by using WALNUT**. Res. Pap, NE-586. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1986. 10 p.

A computer program called WALNUT is described that determines the least-cost combination of lumber grades required to produce a given cutting order of furniture dimension parts. If the least-cost mix is not available, WALNUT can be used to determine the next best alternative. The steps involved in using the program are described.

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

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