REDIRECTING HIGH QUALITY PALLET DECK BOARDS INTO FURNITURE DRAWER SIDES

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ABSTRACT

The desire for more efficient utilization of wood led to research on redirecting higher quality pallet deck boards into furniture drawer sides. Eight pallet companies provided data collection sites for conducting production studies and for estimating the quantity of high quality, clear wood being produced by Michigan pallet mills in 1974. Further studies were conducted under laboratory conditions at the Michigan State University Forestry Department's dry kiln to provide information on packaged handling and drying of pallet lumber. Finally the dried pallet stock was processed into drawer sides at three furniture companies' rough mills.

Analysis of the data collected allowed comparisons of the relative costs of pallet deck boards and drawer sides. Cost reductions will vary between the drawer side dimension stock producing companies depending on their efficiency and lumber costs. The sale of grade pallet deck boards would open a large profitable market for the pallet sawmills. While the demand for drawer side dimension stock is unpredictable because of variations in furniture styles and general economic trends the pallet companies have flexible production operations which could meet a fluctuating demand by shifting emphasis between market options.

REDIRECTING HIGH QUALITY PALLET DECK BOARDS

INTO FURNITURE DRAWER SIDES

By

Edward King Pepke

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INTRODUCTION

Wood is a renewable natural resource yet the need persists to make efficient use of the existing and future raw material. Recognition of the value of increased timber utilization led the United States Department of Agriculture Forest Service to initiate the pallet project at Michigan State University to determine the feasibility of redirecting the higher quality wood from pallet mills to higher value uses. Information for this thesis was obtained by the author from data collected on the pallet project.

Previous studies have indicated the possibility of obtaining furniture quality dimension from log bolts or from cants sawn from pallet mills' bolts.[10,17,19,23,32,36] Tests conducted at pallet mills showed the most reliable approach to obtain lumber suitable for furniture drawer sides was to grade the individual pallet deck boards. Previous results of the Pallet Project[19] present the feasibility of grading the input to pallet mills, logs and cants (squared cross sections of logs with little or no bark), in order to determine the potential for furniture raw material, principally, 2 1/4 inch by 2 1/4 inch squares for turnings. Among the conclusions arrived at were:

> "Using ... oak in absolutely clear lengths is an economic waste and unnecessary in even a quality pallet. With increasingly higher prices offered for the upper grades of these species (including oak), a definite effort should be made to redirect that portion of wood which qualifies for higher value use into furniture type areas. Redirecting high value materials used by many pallet manufactures will require effort on the part of both the pallet manufacturer and the user of high value

> wood. However, on the basis of actual experience to date, under commercial conditions it has proven economically advantageous in several trial cases to both the pallet bolter saw operator and the furniture dimension user."[17]

Another furniture product besides turning squares which might be made from pallet stock is drawer sides and backs. Drawer sides are similiar in width and thickness and are shorter in length than the deck boards cut for pallets. An area for investigation then is the economic advantage, if any, of utilizing stock for drawer sides. This is to be developed in the present study.

Two basic definitions should be stated early: pallets are portable, materials-handling platforms consisting of one or two faces of deck boards, separated or supported by structural members to provide a method of carrying a load with a fork-lift truck, (see illustration on next page). Dimension stock is short, graded pieces of lumber which require little additional processing before fabrication into a furniture component.

PALLET INDUSTRY

The wood pallet industry has expanded very rapidly to fulfill a need in modern materials handling. William H. Sardo, Jr. wrote "Wooden Pallets and Pallet Containers ... Present and Future Markets" which contained the following pertinent passage:

> "The pallet which had its birth in the mid-1930's achieved major use when the military services began to use it to speed the warehousing, handling, and delivery of supplies during World War II. The fork-lift truck and the wooden pallet combination created the 'cubic concept' of modern warehousing, which permits the use of air space as well as floor space in storage areas and transportation vehicles."[38]

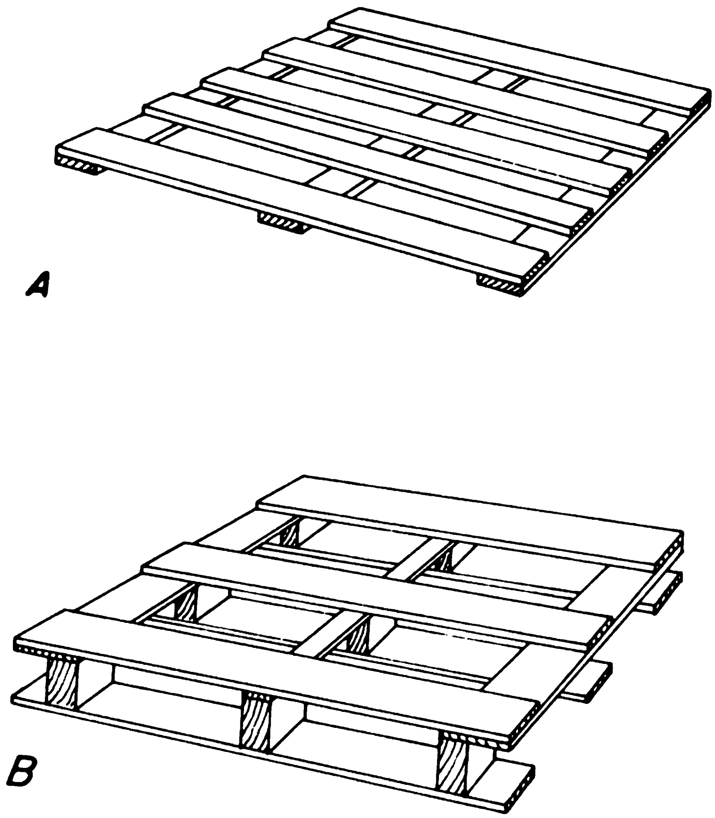


Figure 1.--Expendable pallets: A, no-block type; B, nine-post type.
M 139 428 M 139 430

After World War II the use of pallets achieved rapid growth and popularity. Today "wood pallets are used for material handling, shipping, and storage by just about every conceivable manufacturing and distribution industry, including government agencies. Company, industry-wide, national, and international pallet pools currently exist and are expanding."[43]

Despite the tremendous popularity, which made pallet manufacturing the fastest growing wood products industry, consuming more hardwood lumber than all other hardwood-using industries except furniture manufacturing, the pallet companies have experienced major obstacles. "The main headache of the wooden pallet industry is that it probably has the lowest profit margin of any fabricated wood product. The wooden pallet industry probably has the highest financial mortality rate in the lumber and wood products industries."[38]

Pallet companies being extremely competitive, market directly to the user or others sell their products through a broker or manufacturer's representative.[43] Regardless which method of sales is used, the pallet industry's "growing markets are aggressively threatened by competitive materials and substitute systems."[2] Acknowledging economic problems the progressive mills are exploring alternative markets' potentials. "Additional or better markets for the specific items that can be produced from the material available"[23] could include the sale of pallet deck board lumber for uses other than pallets.

At the last census in 1973 there were 258 pallet mills scattered throughout Michigan's upper and lower peninsula with the heaviest concentration located in the northern half of the lower peninsula.[28] Raw materials are usually obtained in short logs (8 feet and less) or as cants from independent loggers. The logs and cants are purchased either as hardwoods or softwoods by a particular size corresponding to the finished pallet but without regard to grade, other than soundness. The product, pallets, require varied lengths (3 to 6 feet), widths (3 to 6 inches), and thicknesses (3/8 to 1 inch) of deck boards. Deck boards nailed or stapled to runners according to the purchaser's specifications form the finished pallet.

FURNITURE INDUSTRY

The furniture industry is an old, established business in contrast to the pallet industry. While the size of individual companies varies there are over 200 furniture manufacturers in Michigan. Years have been spent by this hardwood-using industry to build a sound reputation for quality and craftsmanship. While centered in Michigan primarily in Grand Rapids and Holland areas, other firms needing hardwood lumber for dimension do exist throughout the state.

Many factors mentioned in the description of the pallet industry are the reverse for the furniture industry: the profit margin is much higher, financial mortality low, and the changes in the economy are felt with less severity. R. M. Hallet's article in the Forest Products Journal, "A Method to Analyze Rough Mill Productivity" says the "efforts at cost reduction should be directed at yields--not productivity."[13] Of course cost reduction ultimately leads to increased profit margins which are the main objective in all furniture firms.

Furniture companies typically select their raw material for each job based on the cost and yield of the graded lumber. "A manufacturing procedure should involve scheduling raw material by grade and size for cutting into a few well chosen grades and sizes of dimension to result in the most economical utilization."[45] Drawer sides are commonly manufactured from red oak or white oak, and maple and vary in length, width and thickness depending on the particular furniture company requirements. Most material for drawer sides comes from grade lumber either directly or as the pieces left from other cuttings. There appears to be considerable variation in the sizes needed and raw material sources for drawer side dimension.

OBJECTIVES

The overall objective of this study was to explore the possibility of redirecting the higher quality lumber from pallet mills into drawer sides for furniture.

Some specific topics for investigation included:

1. To determine the quantity of wood processed by Michigan pallet mills in 1974.
2. To calculate the quantity of higher quality lumber produced at the mills which would be suitable for more efficient uses.
3. To propose a method for handling lumber in the pallet mill, the furniture rough mill, between mills, and the dry kiln.
4. To propose a drying method.
5. To estimate the marketability and demand for furniture drawer side dimension stock.

PROCEDURE

PALLET MILL SELECTION

In the earlier study[19], of which the present study was a continuation, a sample of ten pallet mills was randomly selected from the statewide population of 258 Michigan mills. The mills appeared to have production operations similar to other pallet mills around Michigan. The size of the study mills varied from 15 to 50 employees with corresponding variations in equipment and output. The present study utilized the same pallet mills for sampling and data collection with the exception of two which had altered their production techniques making them incongruent with the needs of the study.

GRADING SYSTEM FOR SELECTION OF HIGH QUALITY WOOD

To establish an appropriate grading system to be utilized in distinguishing between qualities in pallet mills' deck boards the end product--drawer sides must be considered. Because of the non-homogeneous nature of wood every possible combination of defects may be found in lumber. "The size of knots permitted in various pallet parts is governed by the proportion of their width to the width of the piece containing them as well as by their location in the finished pallet part. Though a wide range of knot sizes is acceptable in pallet parts, the referenced pallet specifications should be consulted as they outline the limitations controlling the location and size of permissible knots."[43] Conversely, drawer sides and backs must be free of all but minor defects.

Another consideration in designing the grading system was ease of application. The worker at the pallet mill must be able to rapidly observe a pallet deck board either as it leaves the gang rip saw or as it lays in an output pile and make a judgement whether that piece of lumber should become part of a pallet or part of a furniture drawer.

To meet the above requirements the following grading criteria were established for selecting drawer side stock from cants and lumber:

"Clear" includes:
- Sound knots less than 1/2 inch in diameter
- Maximum of 3 knots per cant or board
- Wane less than 2 inch width on any cant
- Wane less than 1 inch width on any board
- Stain, mineral streak, fleck
- Any defect within 2 inches of an end
- No unsound wood, large checks, or ringshake

DATA COLLECTED AT PALLET MILLS

The data collected at a pallet mill encompassed inputs, measurement of end product yields, classifying or grading the input, denoting the species processed, recording of production time, saw characteristics, and general observations.

Input volumes of cants were determined either from the exterior dimensions of a load of cants or by examining each cant individually. In some mills it was more convenient to measure the exterior dimensions of a load of tightly piled, four-sided, random width cants of equal length and thickness brought to the saw for ripping into lumber. In the case of an in-line system the individual cant dimensions were recorded to the nearest inch before sawing. Before the cants were sawn each was graded by the previously given criteria and the species noted. The volume of clear cants was calculated and divided by the total input of cants to obtain a percentage of clear cant material for that run.

Two basic types of cants were measured in the pallet mills--three-sided and four-sided. While each cant type has four sides because of its square or rectangular profile, the three-sided cants have wane (bark) on one side. Since only a few mills sawed three-sided cants it became desirable to convert their volume to an equivalent volume of four-sided cants. Laboratory tests at Michigan State University which were later confirmed by industry buying practices showed reduction of the three-sided cant volume by 25 percent closely approximated a non-waney, four-side cant. The 25 percent reduction factor was applied to all three-sided cant volumes.

Two methods of measuring the output,which proved to be equally valid, were similar to the measurement of the input. The first method was to measure the tightly-stacked output pile's dimension and compute a cubic foot volume. Another method which gave insignificantly different results was to obtain a piece count of boards in the output pile. The number of boards per pile multiplied by the volume per board also gave the cubic feet of output. When divided by the input and multiplied by 100 the yield in percent may be found:

$$\frac{\text{board output in cubic feet}}{\text{cant input in cubic feet}} \times 100 = \text{Yield in Percentage}$$

The time factor was subdivided into lapse time and production time (P/T). Lapse time was recorded from the time an observation began at a pallet mill until production and/or the observation terminated for that day. Over 25 hours of total lapse time distributed over a seven month period was the designated amount of time to collect data at each mill. The down time (the periods of time the saw did not produce lumber) was subtracted from the lapse time to give the actual total production time.

DATA COLLECTED IN THE LABORATORY ON DRYING LUMBER

Using the Michigan State University Department of Forestry's dry kiln, data was collected on seasoning of the better quality, "clear", pallet lumber. Three different charges were run to examine the effects of thickness and species of boards, kiln schedules, and loading methods. The first charge of oak was subdivided into two 200 board groups, one hit-or-miss presurfaced to 5/8 inch and the other a rough 3/4 inch thickness. Both groups were strapped with steel banding in self-stickered loads capable of being transported by fork-lift truck. A second charge of oak, 3/4 inch thick, unsurfaced, deck boards was dried using typical 3/4 inch stickers spaced about 18 inches apart between layers of deck boards. No steel banding was applied in this latter case. The first and second tests followed the same kiln schedule, T4-D2 from the Dry Kiln Operator's Manual[30]; a third charge followed a slightly different schedule T8-D4 because of a species change to soft maple (kiln schedules appear in appendix). The soft maple charge was self-stickered and banded in two loads suitable for handling by a fork-lift truck.

DATA COLLECTED AT FURNITURE ROUGH MILLS

Three furniture companies' rough mills were another source of data. Three demonstrations were conducted, one per company, to collect data on the feasibility of sawing drawer side dimension from the pallet deck boards which had been graded, kiln dried, and inspected for drying defects. Similar to the methods in the pallet mills the input and output volumes were computed and the yield of dimension stock calculated. Costs of the standard material utilized by the company for drawer sides versus the cost of pallet mills' stock were compared. Figures were obtained on annual volume of drawer sides produced and the amount of lumber purchased to meet that production requirement where available.

RESULTS AND ANALYSIS

DATA TABULATIONS FROM PALLET MILLS

Most of the data collected came from pallet mills with similar types of sawing equipment. Variable factors such as cant input, time, kerf, and end products were equalized for purposes of making comparisons as explained below. Information concerning the amount of clear input, output, output potential, and waste percentages are tabulated and discussed.

EQUIPMENT

At the beginning of the study the majority of the pallet mills had circular-bladed gang rip saws, but by the end of the study all the mills employed the gang saw type of production. A gang saw is a multi-bladed piece of equipment capable of ripping (sawing parallel to the grain direction) cants into lumber. Because it would not be possible to determine the precise percentage of each equipment type in the state, the sample selected and used in this study is assumed representative of the population.

Two types of saw blades were used in the eight pallet mills--insert tooth type and carbide tip. While each type possessed certain advantages and disadvantages, the decrease in kerf was the most significant advantage with carbide-tipped blades. The insert teeth, held in the saw blade by springs, ranged in width from 3/16 to 9/64 inch. A cemented carbide tip on a circular saw is welded to the blade and varies in width from 1/8 to 3/16 inch. For the purpose of comparison of different pallet mills' data the saw tooth type variable was equivocated by assuming that like the sample, the population of Michigan pallet mills was equally divided between carbide and insert-tooth saws.

TIME

Delays in production due to machinery failures, input or output delays, rest stops, and other contingencies created the need for establishing two measures of time--production time (P/T) and lapse time as defined earlier. The following formula was used to calculate down time for the sample mills:

$$\left(1 - \frac{\text{production time}}{\text{lapse time}}\right) 100 = \%\ \text{down time}$$

Down time expressed as the percent of time the saw is not producing averaged 54.0 percent. By employing more efficient production techniques a portion of that precentage of time could be used to increase output. The average was calculated from the eight mills which ranged from a low of 37.7 percent to a high of 76.3 percent with a standard deviation of 12.9 percent (see Table I on page 16). The input and output quantities were necessarily figured using production time and then corrected by the 54.0 percent average down time to allow comparison between firms in Table I.

PRODUCTS

From specific cant thicknesses came corresponding pallet deck board widths. Common deck board widths ranged from 3.5 to 5.5 inches with thicknesses for deck boards beginning at 3/8 inch and merging with runner-sized stock at 1 to 1 3/4 inches. The most observed deck board size, 1/2 inch, was used in making comparisons in Table I. Pallets encompass a wide variation in sizes according to the purchaser's specifications. All board outputs from the gang saws are stacked into lumber piles before nailing operations. For separation of quality lumber for drawer side dimension stock an intermediate step could be imposed to grade and stack the best appearing lumber.

SPECIES

Pallet manufacturers use conventional lumber terms to classify wood as "hardwood" or "softwood"; the exception to the pallet industry is aspen which with its relatively low density is treated as a softwood. Aspen, commonly called popple in the trade, (*Populus grandidentata* and *P. tremuloides*), forms a dominant species in many stands located in Michigan's northern lower and upper peninsulas. Accordingly, for pallet sawmills established within these areas aspen usually constitutes a principal species utilized in pallet production. The other most prevalent species labelled "oak" in the trade is officially several species of red and white oaks (*Quercus*, spp.). When a purchaser failed to specify the particular species or classification of lumber, the pallets were made with mixed, locally available species including oak, aspen, maple (*Acer*, spp.), birch (*Betula*, spp.), basswood (*Tilia americana*), elm (*Ulmus*, spp.) beech (*Fagus grandifolia*), ash (*Fraxinus*, spp.), pine (*Pinus*, spp.), hemlock (*Tsuga canadensis*), etc.

Of the mills observed three processed predominently oak and three processed predominantly aspen. Every mill was capable and actually obtained either oak or aspen as dictated by their purchase orders. While

TABLE I. Pallet Mill Comparisons.

Mill Number	Time		Total Cant Input Observed (Cubic Feet)	Cant Input/ Man-Hour 1/2" Setting (Cu. Ft.)	Percent Clear Cant Input	Total Deck Bd. Output Observed Cubic Feet	Output/Man-Hour Cu. Ft. 1/2" Deck Bds.	Average Yield Percent 1/2"	Est. Cu. Ft. Output/Year Deckboards	Down Time Percent	No. Observations Total	No. 1/2 Inch Observations
1	P/T	13.1	2,478.42	64.48	15.7	1,727.13	46.16	70.5	263,684	42.6	7	5
	Lapse	22.7		37.21			26.64		152,170			
2	P/T	9.62	1,715.32	45.55	13.7	1,200.00	38.06	83.5	249,584	64.4	5	1
	Lapse	27.05		31.43			26.26		88,762			
3	P/T	18.32	1,662.93	62.85	8.6	769.54	44.77	53.4	84,011	61.4	5	1
	Lapse	47.51		34.92			24.87		32,395			
4	P/T	6.56	991.49	31.08	23.0	542.54	16.03	51.6	165,409	76.3	3	2
	Lapse	27.66		25.75			13.37		39,229			
5	P/T	18.57	1,752.02	50.39	11.6	979.65	12.02	31.8	105,509	46.2	7	1
	Lapse	34.48		40.31			9.62		56,824			
6	P/T	15.82	1,790.80	39.91	11.4	1,315.86	31.36	78.4	166,354	47.5	5	2
	Lapse	30.16		30.96			24.09		87,259			
7	P/T	13.92	1,134.94	54.71	19.3	745.58	26.16	65.7	107,124	37.7	5	5
	Lapse	22.33		33.93			16.47		66,778			
8	P/T	23.56	2,923.55	39.88	10.4	1,776.66	26.52	72.2	150,820	55.8	5	2
	Lapse	53.31		27.04			16.56		66,654			
TOTAL	P/T		14,449.47			9,057.46			1,292,495			
	Lapse								590,071			
AVERAGE (per mill)	P/T			48.61	14.21		30.14	65.61		54.0		
	Lapse			32.69			19.74					
STANDARD DEVIATION	P/T			11.73	4.88		12.49	16.66		12.9		
	Lapse			4.92			6.54					

some Michigan furniture manufacturers use aspen, pine, and other softwoods for drawer sides,the majority are oak. Based on past pallet manufacturers' response to buyers' species preferences the pallet industry throughout Michigan would be able to produce high quality stock of the species desired by the furniture manufactures.

Details of the species used at individual pallet mills included in the sample appear in Table II on page 18.

INPUT

The cant input for the eight sample mills totalled 14,449.5 cubic feet (173 MBF or 173 thousand board feet). When divided by the production time for deck boards the result is the quantity of wood used per actual hour of saw operation (input per machine-hour). While the input per machine-hour varies according to the operator speed and infeed rate the range was from 34.4 to 308.5 cubic feet with an average of 139.1 cubic feet per machine-hour and a standard deviation of 57.6 cubic feet per machine-hour (see Table III extrapolation on page 19).

Using the population of 258 pallet mills with 1.125 machines per mill a total of about 80.8 million cubic feet of input per year could be expected in Michigan if there was no down time.

Down time for unavoidable contingencies such as infeed and outfeed delays, rest periods, fatigue allowance, equipment failures, machine maintenance, and so on must be included to provide a realistic estimate of the quantity of wood processed in Michigan pallet mills in 1974. When all the above factors which decrease production were included, the eight sample mills averaged 54.0 percent down time. While this figure may seem high it must be realized that only a few mills operated their gang saw(s)

TABLE II. Cant Utilization for Individual Pallet Mills by Species.

Mill Number	Oak		Aspen		Mixed Species		Lapse Time In Hours
	Volume Cu. Ft.	Percent* Clear	Volume Cu. Ft.	Percent Clear	Volume Cu. Ft.	Percent Clear	
1	1265.6	11.7	807.8	10.6	405.0	21.1	22.72
2	1109.0	23.0	263.7	8.3	342.6	5.3	27.05
3	------	----	-----	----	1662.9	8.6	47.51
4	------	----	991.5	23.0	-----	----	27.66
5	1752.0	11.6	-----	----	-----	----	34.48
6	------	----	1790.8	11.4	-----	----	30.16
7	------	----	-----	----	1134.9	19.3	22.33
8	------	----	1120.7	10.3	1802.9	10.5	53.31
TOTAL	4126.6	----	4974.5	----	5348.3	----	265.22

*Based on volume of clear cants divided by volume of cants processed.

continuously for eight hours; rather the machine would be shut down when the crew switched and performed some other operation or ran another piece of equipment.

When the previously calculated average input based on production time, 139.1 cubic feet per machine-hour is reduced by the 54.0 percent down time the result is 64.0 cubic feet per machine-hour of cant input on the average based on lapse time. The extrapolation to an annual input figure is presented in the following table:

TABLE III. Cant Input Extrapolation

Cubic Foot Cant Input for	Production Time	Lapse Time
Machine-hour	139.1 $ft.^3$	64.0 $ft.^3$
8 Hour Day	1112.8	511.9
40 Hour Week	5564.0	2559.4
50 Week Year	278,200.0	127,972.0
258 Pallet Mills at 1.125 machines per mill	80.8×10^6	37.1×10^6

CLEAR CANT INPUT

As previously explained in the procedure the cant input to a circular gang saw was graded by the simplified grading method. The overall average clear material for the study was 12.9 percent, calculated as follows:

$$\frac{\text{Cubic feet of clear cants} \quad 1,859.13}{\text{Total cubic feet of graded input} \quad 14,449.47} \times 100 = 12.9\%$$

The wide range in percentage volume of clear cants, 34.83, corresponds to the nature of material used in pallet production. The highest value observed, 37.52 percent came from cants sawn from old growth, northern hardwoods. Conversely the low value of 2.69 percent was derived from grading young, pulpwood-sized cants of aspen, many which had traces of wane on each corner. Overall the clear cant input for 258 pallet mills in Michigan for 1974 is estimated to be 12.9 percent times 37.1 million cubic feet of total yearly input yielding 4.8 million cubic feet.

It would be difficult to improve the grade of output from the cants processed presently in Michigan's typical pallet mills. If a system of using deck boards for drawer sides which are primarily oak was adopted, the pallet mills could purchase more hardwood logs to meet the demands. Since the overall percentage of clear material available when the softwoods including aspen were removed was 12.03 percent the amount of clear material would be expected to remain unchanged. Adoption of a grading and selling system for high quality pallet deck boards could provide the economic incentives back through the pallet production system and logging operations to direct efforts into obtaining quality inputs. "Without a strong economic incentive to both buyer and seller it is doubtful that the concept of 'highest value' usage would be accepted."[17]

Grading of the input, which was usually small cants was intended to indicate the amount of clear boards or clear wood which was available. Unfortunately almost all the cants observed were obtained from poor growing, unmanaged Michigan hardwood forests which contain predominantly small trees. Cants sawn from the small trees have "boxed-hearts" (contain the heartwood, pith, and juvenile wood) and therefore do not always yield the same grade deck boards as indicated by the exterior grading prediction, particularily in the case of "clear" cants. The interpolation of the quantity of clear pallet lumber available in Michigan would be valid only in the case of non-boxed-heart cants.

OUTPUT

The lumber output including runners and deck boards for the eight pallet mills observed in the study totalled 10,586.9 cubic feet (127 MBF). Like the input, the division of this total by the production time gives the quantity of wood produced per an actual hour of saw operation. Again the output per machine-hour varies according to operator speed, infeed-outfeed rate, and the tailers' ability. The average output per machine-hour averaged 92.8 with a 44.4 cubic foot standard deviation. The range 245.4 cubic feet was calculated from a high of 266.0 cubic feet and a low value of 20.6 cubic feet. Expanding the output for production time and lapse time by different units of time is shown in the following table:

TABLE IV. Deck Board Output Extrapolation

Board Output in Cubic Feet for	Production Time	Lapse Time (54.0% down)
A Machine-hour	92.8 $ft.^3$	42.7 $ft.^3$
8 Hour Day	742.1	341.4
40 Hour Week	3710.4	1706.8
50 Week Year	185,520.0	85,339.2
258 Mills with 1.125 saws per Michigan Mill	53.9×10^6	24.8×10^6

To calculate the output per man-machine-hour the output per machine-hour is divided by the number of persons operation and tailing the saw. The Table Number VI, presented in the appendix, indicates the statistics for the output of lumber in cubic feet per man-machine-hour for the different conditions involved when two, three, or four men were working the gang rip saw.

The output potential for the Michigan pallet mills is somewhere between the extrapolated production time of estimated output of roughly 53.9 million cubic feet and the lapse time calculated value of 24.8 million cubic feet for 1974. While many factors influence a pallet mill's output including economic conditions, worker motivation, quantity and quality of logs or cants purchased, demand for pallets, working conditions, equipment condition, and so on, the present systems could definitely be improved. If the above conditions were favorable or upgraded the pallet mills could increase production.

Assuming that 28.08 percent of all lumber is clear the total clear quantity of deck boards which could have been redirected into higher quality uses was about 7.0 million cubic feet or 83,464 thousand board feet. Of course almost all of the clear wood went into pallet production in 1974. If as previously discussed the lumber production was increased in the future either by employing more favorable and more efficient conditions the quantity of clear output could be expected to increase proportionately.

While this study began by grading cants for furniture dimension some additional data were gathered by grading stacks of pallet deck boards. The same grading system adapted well to grading deck boards. Obviously some clear deck boards originated from clear cants but other clear deck boards could be sawn from non-clear cants depending on the nature of the cants' defect(s). The results of grading stacks of pallet lumber showed a wide range, 25.3 percent of clear boards, with a high of

37.72 percent and a low of 12.39 percent. The average percentage of clear boards in a stack of lumber, 28.08, with a standard deviation of 9.24 percent shows a higher value than projected by grading the incoming cants, the quantity of clear wood will be best determined from the output figures calculated and discussed in the next section. (Data sheet presented in appendix).

WASTE

The amount of waste encountered in ripping cants into lumber depends upon kerf, lumber size, quality of cants, and the pallet's specifications. While pallet specifications and the cant input quality remained stable from mill to mill the saws tended to be either carbide (about 3/16 inch kerf) or insert-type tooth (roughly 1/4 inch kerf). For the purposes of comparison the most common thickness of lumber produced, 1/2 inch, was used. Investigation into the amount of waste (sawdust, defective wood, etc.) is important because it is a direct reflection of the yield of lumber. Data on waste generated from end trimmings was not measured and is therefore not included.

To calculate the data for Table V a given input quantity of wood from a day's production of 1/2 inch deck boards was divided into the actual quantity of 1/2 inch boards produced. The result is the yield in percent which when subtracted from 100 percent gives the percent of waste. The composite data appears on the next page:

TABLE V. Waste Data For 1/2 Inch Deck Boards

Saw Tooth Type	High Proportion (%)	Low Proportion (%)	Range (percent)	Average (percent)	Standard Deviation (percent)	Number of Observations
Carbide	29.51	21.57	7.94	26.29	4.18	9
Insert	47.80	28.86	18.94	35.52	7.63	5

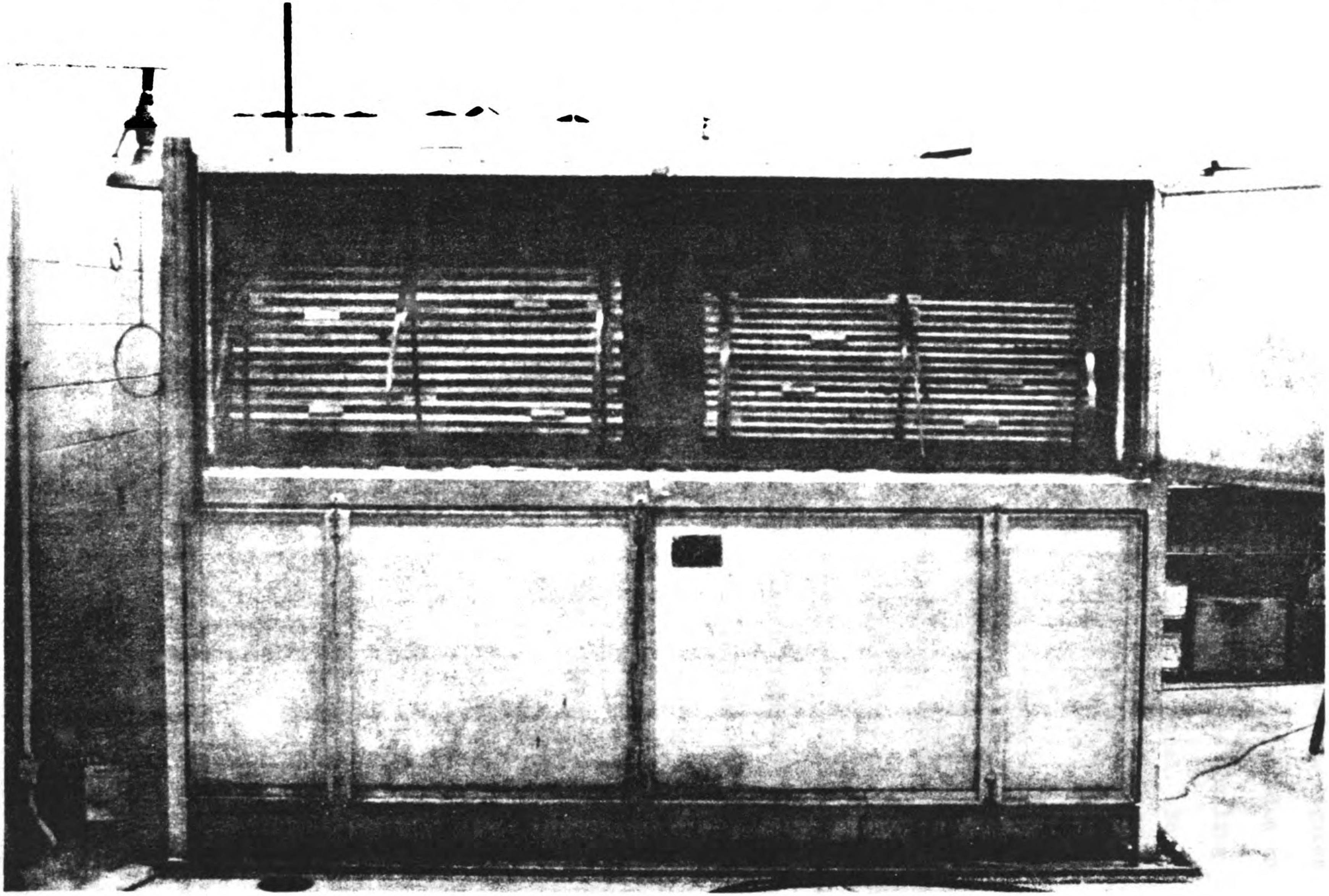
These comparisons were difficult to make due to limited observations of 1/2 inch lumber. The above data used three-sided cants with volumes reduced by 25 percent to equate to four-sided cants to calculate the percent waste from inserted-tooth saws. The inserted tooth data also came from five observations at one mill's machine. Others showed waste factors but not enough observations were made at each mill to calculate significant statistics.

DATA COLLECTED IN THE LABORATORY ON HANDLING AND DRYING

Experimentation with various drying techniques at the Michigan State University dry kiln resulted in information relative to both drying and handling. "One of the major methods of reducing costs in the sawmill (and rough mill) today is in developing good and efficient lumber-handling techniques."[12]

In the first kiln charge (see photo, page 25) of unsurfaced (rough) and presurfaced 3/4 and 5/8 inch respectively red oak pallet deck boards the presurfacing had significant advantages. The thinner lumber dried faster and more evenly to the desired final moisture content of seven percent from an original 33.7 percent than the rough lumber; the kiln conditions followed schedule T4-D2 from the Dry Kiln Operator's Manual.[30] A major advantage of presurfacing was that the thinner boards

Figure 2. Laboratory Dry Kiln with Rough Load on Left and Presurfaced Load on Right.

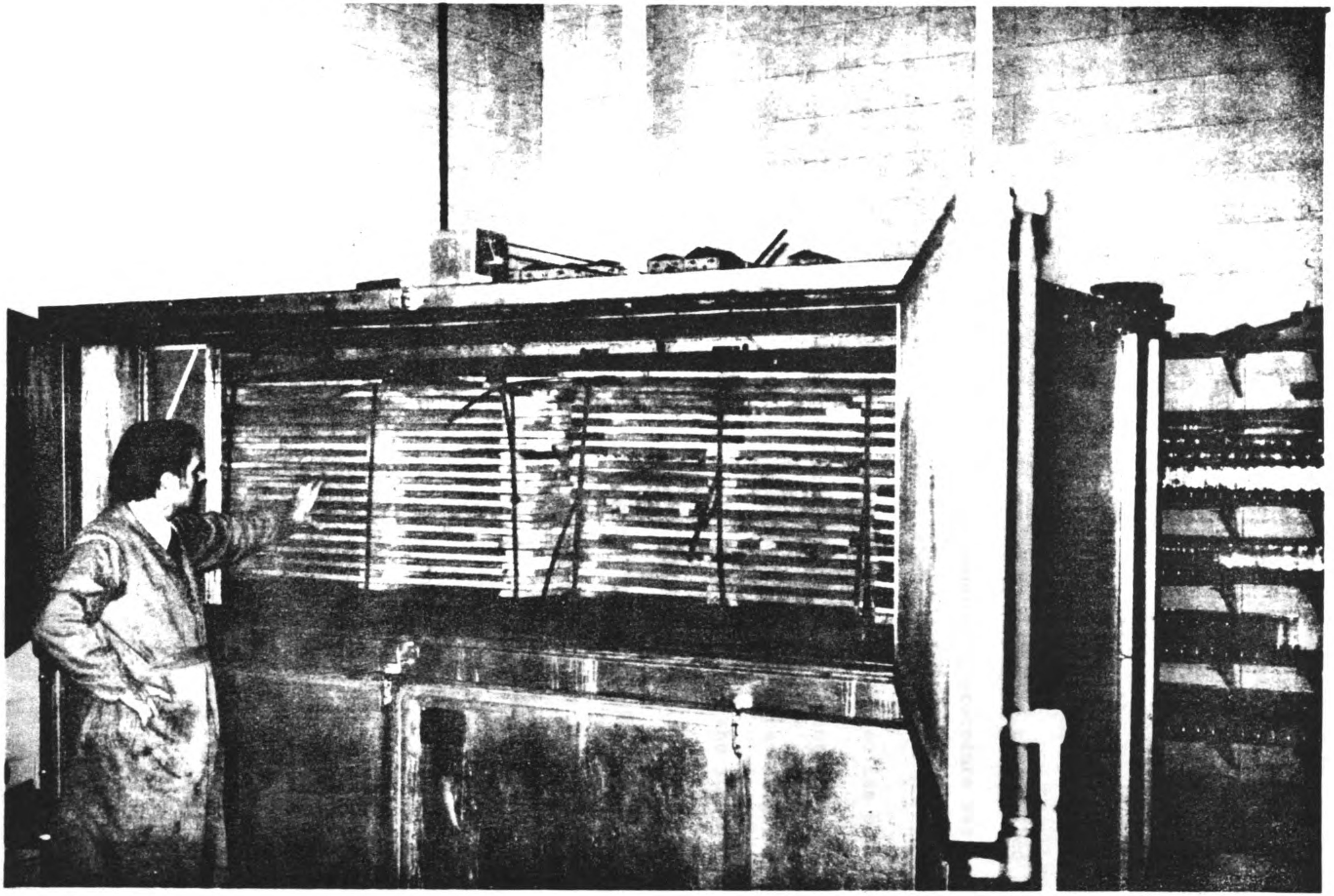


consumed 11.2 percent less kiln space. Although the smoother, lighter presurfaced boards were easier to handle, the true test--conversion to drawer side stock at the furniture company rough mill showed handling and processing of either rough or presurfaced wood to be equal. No difference in surface checking was observed and stress tests showed all stresses to be relieved after conditioning.

The second drying experiment employed a similar material and kiln schedule--3/4, rough sawn, red oak, pallet deck boards, and T4-D2. The method of loading the kiln proved to be the significant outcome of this second charge of oak. The deck boards were stacked tightly side-by-side and stickered with dry, 3/4 by 1 1/2 inch kiln stickers. Because no steel strapping was used to keep the stacked lumber tight during drying, the boards warped significantly more than in the previous charge of banded deck boards. The effect of increased warp, crook, bow, and cup, was partially nullified at the furniture company's rough mill due to short, thin size of the cuttings produced for their particular drawer sides.

The third test charge of 4/4, soft maple, pallet deck boards was again banded which restrained warp (see photograph, page 27). A disadvantage of banding was the discoloration to the six self-stickered stickers on the outside of the pile. No loss was incurred as the stain was expected; therefore low grade deck boards of lesser value were used in these six positions. The anticipated result of quick drying from green to seven percent occurred in approximately 100 hours without drying defects. The Dry Kiln Operator's Manual[30] kiln schedule, T8-D4, may be found in the appendix.

Figure 3. Laboratory Dry Kiln with Third Test Charge of 3/4 Soft Maple.



The method of restraining the deck boards from warping during drying requires further elaboration. Three rows of steel strapping encircled each pile which were fastened at a convenient location in the normal manner using strapping clips. A major difference was that two "tails" were fastened to each band with the same slips allowing retensioning of each strap as necessitated during drying, (see the photo on page 29). Old clips were cut off with tin snips and a new tail pulled taunt before another clip was applied. The tensioning procedure was repeated once or twice for each package in the test charges.

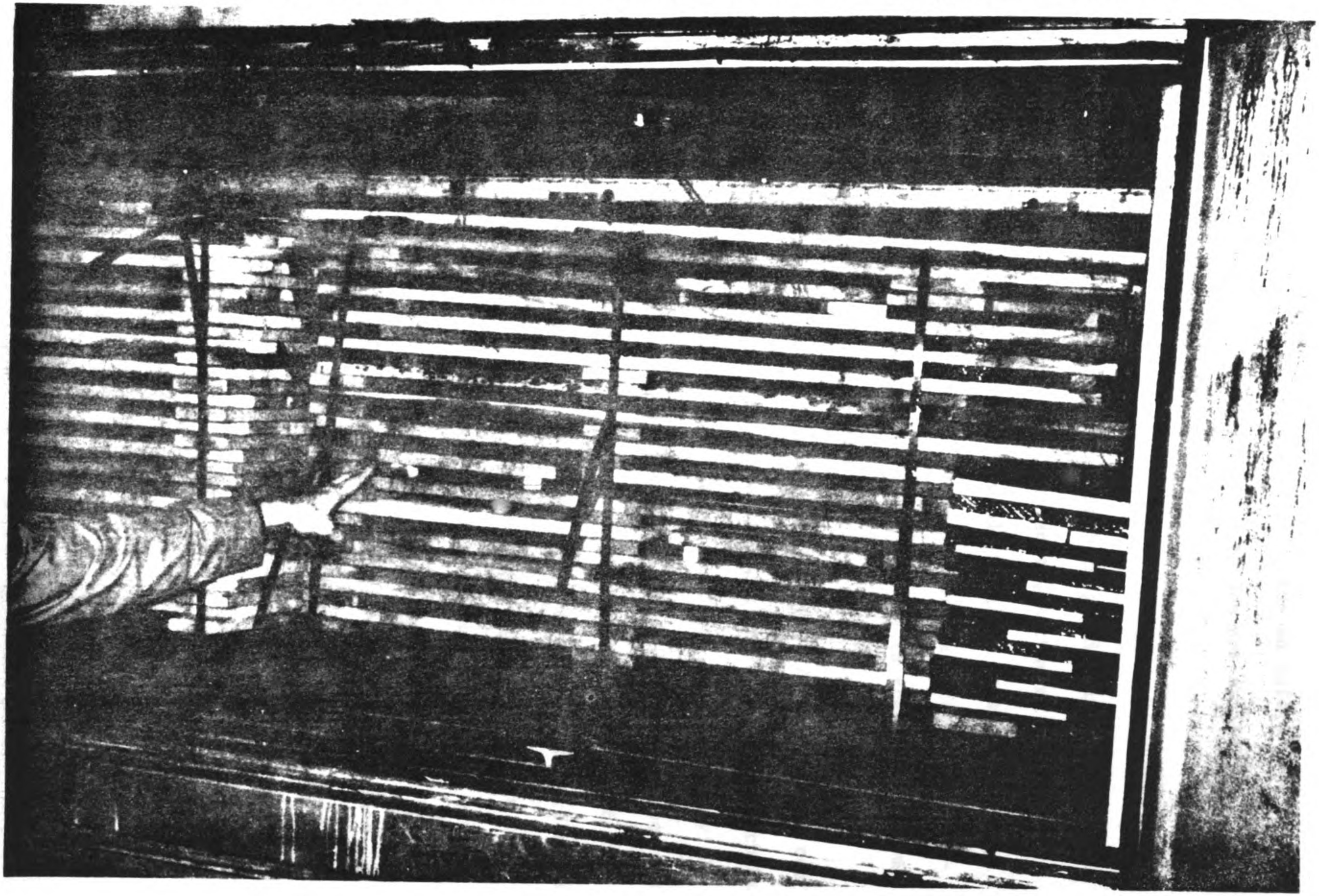
The bundling of the lumber for drying also facilitated its handling by fork-lift trucks which are common pieces of equipment in both pallet mills and furniture companies. The self-stickered packages were designed to be easily stacked and strapped on a pallet at the lumber producers. Jigs for uniform, square-sided stacks with sticker guides for correct alignment would ease stacking at the pallet mill. The package could be fork-lifted to a truck, transported to a furniture company, fork-lifted directly into the dry kiln, and finally fork-lifted or carted into the rough mill. (See Process Flow Chart in the appendix).

Overall the kiln schedules applied to the oak and maple lumber packages dried the deck boards to the desired moisture content, with a minimal amount of defects, in a minimum amount of kiln time. The packages will facilitate handling between mills as well as restraining the lumber during drying.

DATA COLLECTION AT FURNITURE ROUGH MILLS

Samples of pallet deck boards processed at three cooperating furniture rough mills became high quality furniture drawer side stock.

Figure 4. Banding Method with Extra Tails for Restraint during Drying and Ease of Handling.



Attention was placed on material costs and yields as information on the handling, drying, gluing, and machining costs was not available.

FIRST ROUGH MILL TEST

The production sequence at the first rough mill involved cutting a deck board to the desired drawer side length, surfacing to the rough thickness, and ripping to width which would be glued together to the rough dimension of a drawer side; other mills used a different production sequence. Although the complete data appears in the appendix some pertinent results will be presented here.

The first test utilized some of the 3/4 by 3 1/4 by 47 inch, red oak, seven percent moisture content, pallet deck boards dried at Michigan State University. After all inputs and outputs were measured the yield was computed by surface measure (disregard thickness) to be 60.6 percent. It should be explained that only two cutting lengths were sawn, 16 5/8 inches and some 46 7/8, which is contrary to normal production procedures. Usually three or more cutting lengths provided to the cut off saw make the most efficient use of the incoming stock's lengths. With a variety of possible cutting lengths, clear cuttings may be obtained that best fit the rough lumber lengths (especially with short lengths), avoid defects within the piece, and produce the least waste. In Aubrey E. Wylie's article, "Lumber Grades and Sizes in Relation to Product Yields" he comments on the necessity of increasing the number of cutting lengths:

> "There can be no doubt that one cutting length at a time would be ruinous. Any improvement beyond three or four sizes would depend upon a reduction of the differences between sizes chosen. As the number of cutting lengths in the group increases the maximum loss becomes a function of the spacing of lengths chosen."[45]

Another peculiarity of this case was that the widths to rip saw, 2 5/32 inches, were incongruent with the deck board width of 3 1/4 inches. The excessive waste at the rip saw only compounded the cut-off saw waste to give that final low yield figure, 60.6 percent. Many furniture companies avoid the extra waste occurring from ripping by edge gluing boards to form a long continuous panel moving through an electronic bonding machine such as the Raybond model. The panel's width corresponds to desired drawer side length; the rough width of each drawer side is obtained by ripping the long, glued panel to the designated size. The advantage of this system, used in the other two sample rough mills, is a reduction in waste and increase in yield.

The actual cost of the drawer sides is obtained by dividing the original cost of lumber by the final yield:

$$\frac{\text{Cost of Lumber \$/MBF}}{\text{Yield \%}} = \text{actual cost \$/MBF}$$

The calculating of actual yields and costs allows comparison of the use of pallet deck board lumber to normally-used grade lumber. In this first furniture rough mill the estimated cost of "clear" pallet lumber was $200.00 per thousand board feet delivered to the plant green. Dividing by the 60.6 percent yield gives a true cost of lumber to be $330.03. Normally the furniture company experiences a 60.0 percent yield from the 3/4, #1 and #2 common oak, including delivery, which costs $171.95 per thousand board feet green. Division of the cost by the yield shows the actual cost of drawer sides and backs to be $286.58 when using graded lumber. The cost of kiln drying will increase the costs of the drawer sides.

Obviously, the cost of using pallet lumber would mean an increase in raw material price if yield were always this low. Unfortunately the uncustomary production operations employed during an economic and production decline distorted the value of the above data.

SECOND ROUGH MILL TEST

The pallet stock cut at the second furniture company's rough mill was the kiln dried, 3/4 soft maple. In comparison with the former test this mill had four cutting lengths, 17 5/8, 20, 24, and 27 inches, which made more efficient use of the 40 and 48 inch pallet deck boards. After cross-cutting to length and ripping to width for edge gluing into drawer sides the output divided by the input gave an average yield, (two loads were run), of 87.2 percent. This high yield partially resulted from the fact that the drawer sides were an exact multiple of the deck board dimensions. With 68.0 percent being the normal yield in this company's rough mill production of furniture drawer sides, the 87.2 percent yield compares favorably.

To further emphasize the difference between the use of pallet stock over the normal use of grade lumber the true cost of one-thousand board feet used to produce drawer components may be calculated. The purchase cost of the delivered, green lumber divided by the yield gives the real cost of the processed drawer sides (see below).

$$\frac{\text{Pallet Stock Cost}}{\text{Yield}} = \frac{\$200.00/\text{MBF}}{88.4\%} = \$227.27/\text{MBF}$$

$$\frac{\text{Average Normal Grade Lumber Cost}}{\text{Yield}} = \frac{\$204.67/\text{MBF}}{68.0\%} = \$300.98/\text{MBF}$$

Excluding kiln drying costs, which should be lower for the pallet stock, a drawer side producer could expect to save $73.71 per thousand board feet of actual dimension produced. Compounded over a month's or year's time the cost reduction could be substantial; unfortunately the company involved in this test could not estimate their yearly production quantity of drawer sides.

THIRD ROUGH MILL TEST

The third kiln dried charge of 3/4 rough and 5/8 inch presurfaced red oak contained approximately the same amount of lumber as the two other trials, 371 board feet. The expected advantage of no rough surfacing needed at the furniture company was negated when all of the deck boards were planed to 9/16 inch. Correlation between the three cutting lengths, 15 1/8, 18, and 29 inches, and the 49 inch lumber was high but failure to remove previously set aside boards marked for defects led to a lower than expected yield of 77.4 percent based on surface measure (see complete data in appendix).

Calculation of the actual cost of one-thousand board feet of lumber used to produce drawer sides allows comparison of normal input of grade lumber and the alternative raw material of pallet stock:

$$\frac{\text{Pallet Stock Cost}}{\text{Yield}} = \frac{\$200.00/\text{MBF}}{77.4\%} = \$258.40/\text{MBF}$$

$$\frac{\text{Average Normal Grade Lumber Cost}}{\text{Normal Yield}} = \frac{\$244.00/\text{MBF}}{55.0\%} = \$443.64/\text{MBF}$$

The difference in actual cost per thousand board foot of drawer sides, \$185.24, was larger than savings calculated for the two previous trials. Part of the reason for the higher amount of savings became apparent when this third firm disclosed that their drawer side stock was purchased along with lumber for other parts. There is no distinction made as to lumber for exclusive use as drawer sides, but rather the lumber for drawer sides allegedly comes from other components' lumber cut backs. Obviously the drawer side raw material can not be termed "scrap"--the furniture manufacturer pays for the lumber.

DEMAND FOR DRAWER SIDES

Sampling in three furniture companies showed that drawer side dimensions vary widely; it would be impossible to choose a common size. Similarily the demand for drawer sides fluctuates within each firm as well as between different firms. One company was able to offer an estimate of their yearly annual consumption of drawer sides--300 thousand board feet. Another company calculated that "a portion" of their purchase of 25 thousand board feet of soft maple went for drawer side production. Still another major Grand Rapids furniture manufacturer stated that the 25,000 pieces of furniture produced annually required about one million board feet of drawer side dimension stock. The president of a furniture company making lower-cost furniture stated that scrap from four by eight foot sheets of particle board was used for their drawer parts.

The preceding figures indicate the inconsistent quantities of drawer sides and backs that the different furniture companies consume. Factors which influence the board footage of drawer sides produced include style of furniture, price of furniture, and quantity of particular pieces produced. Because many manufacturers did not know the amount or would not give the amount of drawer sides required, no accurate figures could be estimated for drawer side demand.

RELATIVE COSTS

To offer some tangible means for evaluating the advantage of using graded pallet lumber as the raw material for the manufacture of furniture drawer sides the actual monetary values must be attached to the respective materials and processes.

Discussions with pallet lumber producers gave insight to a few costs. The costs of lumber production in pallet mills as described by Yaptenco, Harold, and Wylie in their publication on pallet manufacturing costs, include handling, trimming, slatting, canting, material, and overhead (composed of "administrative overhead, taxes, insurance, depreciation, supplies, and maintenance.")[46] Based on general economic conditions, which were relatively poor at the end of 1974 and the beginning of 1975, pallet manufacturers quoted a price of about $200.00 per thousand board feet of green, 4/4, oak deck boards including shipping or delivery to the furniture plant in stacked, steel-strapped, palletized packages.

Before conversion to dimension stock at furniture rough mills additional handling to and from the dry kiln and to the rough mill would be incurred. A drying cost and possible storage cost might be included. Self-stickering coupled with unitized packages should reduce appreciably the normal price of kiln drying lumber. Edward M. Conway in a Forest Products Journal article titled "Factors That Affect the Cost of Hardwood Kiln Drying"[8] stated:

> Costs depend "upon its beginning and final moisture content, the uniformity of moisture content required, the quality of the drying, the efficiency of the kiln plant, the know-how of the operator, the local labor costs, the proper quantity for the charge, the mechanization of handling, the assigned proportion of company burden, and many other factors. These considerations are in addition to the obvious variables of power rates, fuel costs and heat transfer efficiency,

maintenance, fire insurance, sticker breakage, and depreciation on kilns and equipment. In America today, few industrial processes in any field have as widely varied costs as the kiln drying of a unit of hardwood lumber."[8]

Typical prices paid by furniture manufacturers for lumber used in drawer side production vary between plants and their lumber sources. A low figure of $151.00 per thousand board feet of number 1 and number 2 common grade was found at one furniture company. Another firm used better quality lumber for drawer stock and paid $244.04 per thousand board feet. This latter firm purchased drawer side stock by obtaining excess stock for other furniture parts and using what they termed "scrap" for drawer sides.

As reported earlier the actual cost of the drawer sides was determined by dividing the purchase price of the lumber by the yield at the end of the rough mill. Actual cost of grade lumber was $286.58 to $443.64 per thousand board feet based on yield; but the actual cost of the selected deck boards was $227.27 to $330.03 per thousand board feet, including delivery charges.

The above figures were collected at furniture company rough mills but would be applicable to dimension stock producers who could also manufacture drawer sides. From "Cost Analysis for Wood Products Manufacturing" by Henry A. Huber and George Vasiliou comes the following quote:

> "For example, 7/16-inch drawer sides and backs can be purchased, FOB mill, for about 82 percent of the cost of making them. The company should investigate the possibility of a standardization program to reduce the number of cross-sections of drawer stock required. It then might be possible to buy such stock processed through the moulder (but not to finish length), in a few single or multiple lengths. In this way, the company could maintain control over the critical areas of shoulder lengths and joint details, but still take advantage of volume purchasing."[15]

While buying drawer stock dimension might have advantages; each company would have to accurately assess their own costs. The dimension producer certainly is a key market for the pallet mill lumber companies.

FUTURE PREDICTIONS

In these unstable economic times it becomes difficult to evaluate and predict future trends. Some values will be pertinent regardless of general economic conditions. Those values are the relatively high overall savings incurred when sawing drawer sides from quality pallet stock rather than grade hardwood lumber.

To the pallet industry whose business fluctuates much more than the normal economy, alternative product markets are needed to smoothen operations. Fluctuations occur because "pallets are required before any manufactured parts or finished goods can be delivered. As the manufacturing tempo increases, more pallets are required and when orders for manufactured goods decline so does the need for pallets."[16] One strong market for products which could be produced by Michigan pallet mills without altering basic present production methods would be to produce drawer side quality material for furniture companies.

Regardless which way the United States' economy moves the Michigan pallet mills will have to broaden their products and/or increase pallet sales to operate more profitably. "More time should be spent trying to find additional or better markets for the specific items that can be produced from the material available."[23] Obviously the sale of deck boards for dimension stock to furniture manufacturers or dimension producers would be one feasible market.

The furniture producer cannot escape the unfavorable economic conditions surrounding the United States, including the wood products industry. Even in more prosperous times the furniture company would aspire to increase their profit margin by lowering production costs or material costs. In R. M. Hallet's method of analyzing rough mill productivity he stated that "efforts at cost reduction should be directed at yields--not productivity."[13] From previously presented data the results indicated that yields at furniture rough mills are very significantly higher when employing the graded pallet stock as the raw material.

Although economists disagree as to the immediate economic future of the nation, the preceding leads to the conclusion that the productivity and efficiency of the furniture and pallet firms could be improved. The more progressive firms will be first to analyze and implement the application of the new product market or raw material source in relation to their business. Assuming that the data previously presented is correct then adoption of the proposed system of redirecting pallet mill produced deck boards into furniture drawer sides should prove profitable, as well as conserving natural resources in the long run.

CONCLUSIONS AND RECOMMENDATIONS

Based on the data collected and analyzed from Michigan pallet and furniture manufacturing companies the following conclusions on redirecting pallet deck boards into furniture drawer sides may be drawn:

1. The sale of pallet deck boards possessing the best appearences would be a profitable, alternative market for pallet sawmills.
2. Utilizing pallet lumber for dimension stock at a furniture company or dimension producer for drawer side production would result in cost reduction over the use of grade lumber.
3. It is estimated that 24.8 million cubic feet of mixed species lumber, of which 7.0 million cubic feet was clear, was produced by Michigan pallet mills in 1974.
4. Since graded pallet lumber would have few defects the high yields resulting from integration of this material into furniture drawer side production would be a function of the correlation between cutting lengths and the original lumber length.
5. The grade of a given cant is not always indicative of the quality of each piece of lumber sawn from said cant, especially in the cases of boxed-heart cants.
6. With only minor modifications to production operations the pallet mills could meet the demand for high quality wooden drawer side dimension stock.

7. The inclusion of kiln dried pallet stock for remanufacture into drawer sides would have a negligible affect on the normal production operations throughout a furniture plant beyond the rough mill.
8. The two class, clear or non-clear, grading system was applicable to both cants and deck boards; grading was quick, accurate, and simple.
9. Self-stickered, steel-strapped, palletized packages of deck board lumber stacked at the pallet mill may be transported by fork-lift truck from the pallet mill to the dry kiln, dried, and fork-lifted to the rough mill.
10. Close attention to the moisture content-based steps of the Dry Kiln Operator's Manual kiln schedule successfully dried the 3/4 inch lumber quickly and evenly to the desired seven percent moisture content; with experience time-based steps for the same kiln schedule will allow increased ease of operation.
11. It was impossible to accurately estimate the demand for drawer sides by Michigan furniture manufacturers due to complicated variables in each company's drawer side production.

The recommendations presented here stem from the research done on increasing utilization of hardwood lumber by redirecting high quality pallet deck boards into dimension stock:

1. Several furniture companies should attempt a series of trials to evaluate the potential cost reductions for

their particular firm; publication of their results would provide valuable decision making tools for other companies.

2. The pallet deck board lumber would have other uses aside from drawer sides such as structural components for furniture which should also be investigated.

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APPENDICES

APPENDIX A

DRY KILN OPERATOR'S MANUAL KILN SCHEDULE FOR 4/4 RED OAK T4-D2

TEMPERATURE STEP NUMBER	WET BULB DEP. STEP NUMBER	MOISTURE CONTENT AT START OF STEP	DRY BULB TEMPERATURE °F	WET BULB DEPRESSION °F	WET BULB TEMPERATURE °F	RELATIVE HUMIDITY	EQUILIBRIUM MOISTURE CONTENT
1	1	50+%	110°	4°	106°	87%	17.5%
1	2	50 %	110°	5°	105°	84%	16.2%
1	3	40 %	110°	8°	102°	75%	13.3%
1	4	35 %	110°	14°	96°	60%	9.9%
2	5	30 %	120°	30°	90°	31%	5.4%
3	6	25 %	130°	50°	80°	10%	2.0%
4	7	20 %	130° 140°	23° 50°	107° 90°	47% 14%	7.3% 2.6%
5	8	15 %	130° 180°	10° 50°	120° 130°	73% 26%	12.1% 3.3%

*The figures above steps 7 and 8 are suggested equalizing and conditioning treatments by Dry Kiln Operator's Manual.

**Figures for steps 7 and 8 are FPL 1951 schedule.

APPENDIX B

DRY KILN OPERATOR'S MANUAL KILN SCHEDULE FOR 4/4 SOFT MAPLE T8-D4

TEMPERATURE STEP NUMBER	WET BULB DEP. STEP NUMBER	MOISTURE CONTENT AT START OF STEP	DRY BULB TEMPERATURE °F	WET BULB DEPRESSION °F	WET BULB TEMPERATURE °F	RELATIVE HUMIDITY	EQUILIBRIUM MOISTURE CONTENT
1	1	50+%	130°	7°	123°	81%	14.0%
1	2	50 %	130°	10°	120°	73%	12.1%
1	3	40 %	130°	15°	115°	62%	9.7%
1	4	35 %	130°	25°	105°	43%	6.8%
2	5	30 %	140°	40°	100°	25%	4.1%
3	6	25 %	150°	50°	100°	8%	2.9%
4	6	20 %	160°	50°	110°	21%	3.2%
5	6	15 %	180°	50°	130°	26%	3.3%
			170°		160°		

APPENDIX C

RESULTS OF GRADING INDIVIDUAL PALLET DECK BOARDS

Data Collected at Mill #5 Species: Oak				Stock Size
Trial #1	113 Boards	(175.6 bd. ft.)	12.39% Clear	7/8 x 5 1/2 x 46 1/2"
Trial #2	228 Boards	(225.5 bd. ft.)	37.72% Clear	7/8 x 3 1/2 x 46 1/2"
Trial #3	127 Boards	(125.6 bd. ft.)	37.00% Clear	7/8 x 3 1/2 x 46 1/2"
Trial #4	216 Boards	(337.5 bd. ft.)	28.70% Clear	7/8 x 5 1/2 x 46 3/4"

Data Collected at Mill #4 Species: Soft Maple				Stock Size
Trial #1	320 Boards	(226.7 bd. ft.)	34.38% Clear	3/4 x 4 x 40"
Trial #2	554 Boards	(1,108.0 bd. ft.)	21.48% Clear	1 1/2 x 4 x 48"

Data Collected at Mill #5 Species: Oak				Stock Size
Trial #1	1,737 Boards	(1,411.3 bd.ft.)	24.87% Clear	3/4 x 3 1/4 x 48"

Data Collected at a Non-sample Mill Species: Oak				Stock Size
Trial #1	1,092 Boards	(1,251.3 bd.ft.)	6.14% Clear*	3/4 x 5 1/2 x 40"
Trial #2	327 Boards	(374.7 bd. ft.)	6.42% Clear*	3/4 x 5 1/2 x 40"

*High quality material had been previously graded and removed

APPENDIX D

Table VI. Outputs Per Man-Machine-Hour (Cubic Feet)

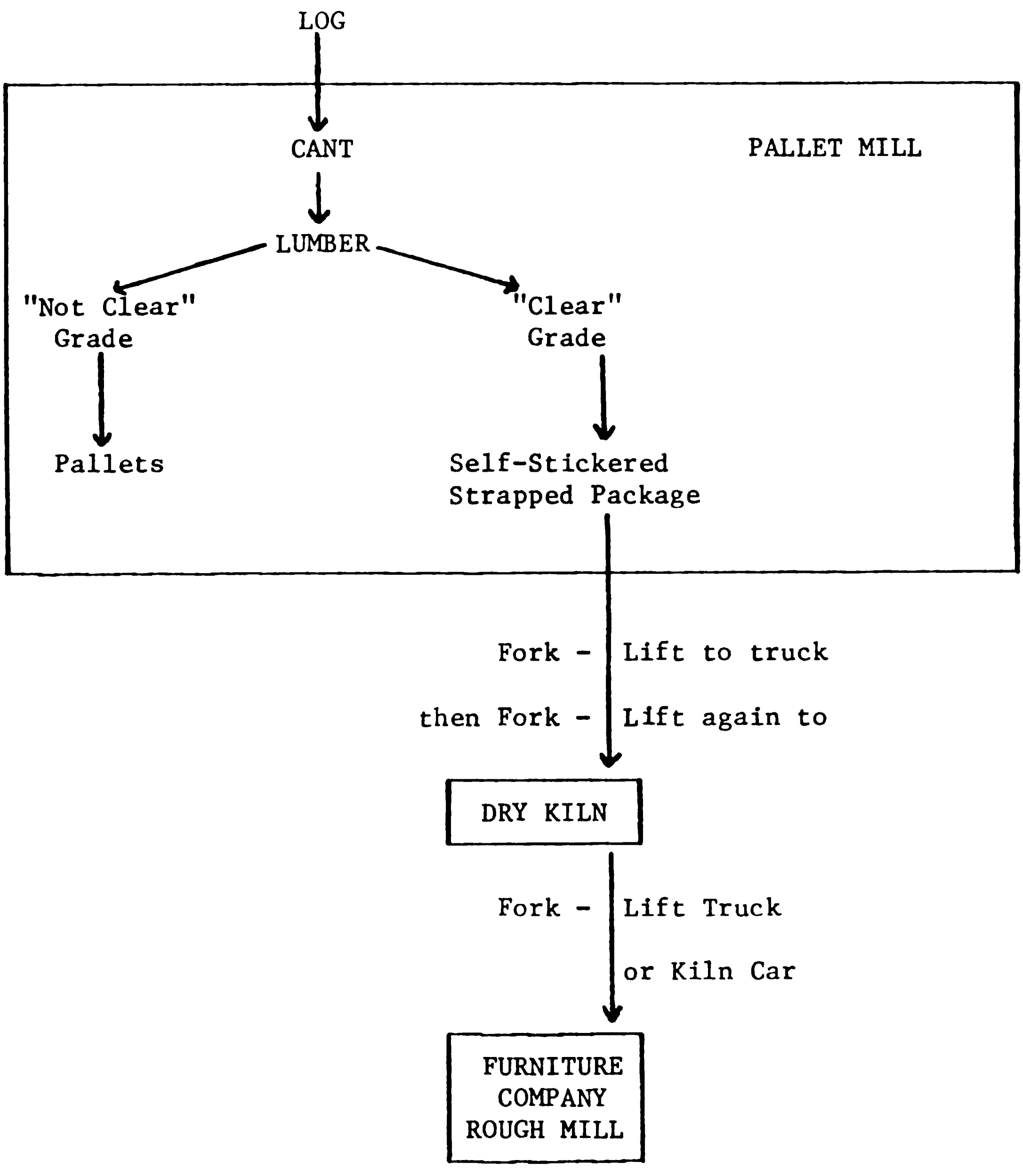
Number of Men	High Value	Low Value	Range	Average	Standard Deviation	Number of Observations
2	68.33	21.85	46.48	39.17	15.11	23
3	88.66	12.02	76.64	42.67	22.75	20
4	38.06	25.52	12.54	33.47	5.81	4
		Combined Average		40.17		

Some interpretations concerning the statistics presented in the table should be offered. The ranges for the outputs were wide due to the variety of lumber sizes produced. Saw speeds kept approximately the same revolutions per minute whether 1/2 or 1 1/2 inch lumber was cut. But the infeed-outfeed rate for 1/2 inch boards was relatively slower than for thicker lumber. This was especially true when the less-powerful saws had to cut six, 1/2 inch deck boards from a five inch wide cant versus three 1 1/2 inch wide runners from the same width cant for an example.

The average output per man-machine-hour for two men and three men was only 3.5 cubic feet different. As in the input per man-machine-hour this slight gain in output by using one more man was negated by increasing the infeed material by the saw operator. While the output increases by adding a second tailer to a saw, the output per man-machine-hour remains approximately the same. One additional man tailing, four total men, proves to be extra labor since the output per man-machine-hour decreases. More idle time occurs when four men work one saw since the operator cannot feed beyond a saw's maximum rate. The idle time did not constitute wasted labor however if the extra time was used for sorting, stacking, off-bearing loads of lumber, etc.

APPENDIX E

Figure 5. Process Flow Chart



APPENDIX F

FIRST FURNITURE COMPANY YIELD STUDY
March 10, 1975
RUN #1 -- NO DRYING DEFECTS

INPUT

289 pieces of pallet deckboard, oak

289 (3/4" x 3 1/4" x 47") = 307 bd. ft. by Surface Measure

CUT OFF → SURFACER → RIP SAW

Because of a sales decline the operations were observed at limited production. Only two sizes of drawer sides were sawn; much higher yields would be possible with more cutting lengths and random widths.

OUTPUT

325 pieces (5/8" x 3 1/4" x 16 5/8") = 122 bd. ft.
91 pieces (5/8" x 2 5/32" x 46 7/8") = 64 bd. ft.

186 bd. ft. total

YIELD

$$\frac{186 \text{ bd. ft.}}{307 \text{ bd. ft.}} \times 100 = 60.6\%$$

****

RUN #2 -- CONTAINED ALL DRYING DEFECTS

INPUT

60 pieces (3/4" x 3 1/4" x 47") = 64 bd. ft.

CUT OFF → SURFACER → RIP SAW

OUTPUT

89 pieces (5/8" 3 1/4" x 16 5/8") = 33 bd. ft.

YIELD

$$\frac{33 \text{ bd. ft.}}{64 \text{ bd. ft.}} \times 100 = 51.6\%$$

****

COSTS

Normal material used for drawer sides: 3/4", #1 and #2 Common, Oak

$$\frac{\text{Cost of Lumber}}{\text{Yield}} = \text{actual cost of drawer sides produced in the rough mill.}$$

$171.95 MBF not kiln dried / Yield 60.0% = $268.58

Pallet deckboards - an alternative drawer side material 3/4", green oak, clear, delivered, not kiln dried.

$$\frac{\text{Cost of Lumber \$200.00 MBF}}{\text{Yield 60.6\%}} = \text{\$330.03 MBF actual cost plus drying costs.}$$

APPENDIX G

SECOND FURNITURE COMPANY YIELD STUDY
March 14, 1975

INPUT

166 pieces (3/4 x 3 3/4 x 48") = 207.5 bd. ft. by surface measure

maple

159 pieces (3/4 x 3 3/4 x 40") = 165.5 bd. ft. by surface measure

373.1 bd. ft. by surface measure

CUT OFF

332 pieces (3/4 x 3 3/4 x 24") = 207.5 bd. ft. by surface measure

214 pieces (3/4 x 3 3/4 x 20") = 111.5 bd. ft. by surface measure

319.0 bd. ft. by surface measure

52 pieces (344 x 3 3/4 x 40") = 54.1 bd. ft. were set aside for running full length through the moulder for conversion into 3/4 x 3 1/2 x 17 5/8 and 27".

Percent of input yielded = $\frac{319.0 \text{ bd. ft.}}{319.0 \text{ bd. ft.}}$ = 100.0%

(319.0 is 373.1 less 54.1 removed)

RIP SAW

21 Layers	48.75 x 24" =	170.6 bd. ft. by surface measure
1 Layer	41.75 x 24" =	7.0 bd. ft. by surface measure
14 Layers	50.50 x 20" =	98.2 bd. ft. by surface measure
1 Layer	17.50 x 20" =	2.4 bd. ft. by surface measure
		278.2 bd. ft. by surface measure

OUTPUT

$$\text{Percent of input yielded} = \frac{278.2 \text{ bd. ft.}}{319.0 \text{ bd. ft.}} = 87.2\%$$

****

COSTS

$$\frac{\text{Normal drawer side material cost}}{\text{Normal Yield}} = \frac{\$204.67/\text{MBF}}{68.0\%} = \$300.98/\text{MBF}$$

$$\frac{\text{Pallet Lumber Cost}}{\text{Yield}} = \frac{\$200.00/\text{MBF}}{87.2\%} = \$229.33/\text{MBF}$$

APPENDIX H

THIRD FURNITURE COMPANY YIELD STUDY
April 16, 1975

INPUT

342 pieces of pallet deckboard, oak

342 (3/4" x 4 1/4" x 49") = 495 bd. ft. by surface measure

SURFACE to 9/16"

CUT OFF

Length	Pieces	Width	Bd. Ft.
29	326	4 1/4"	279
18	299	4 1/4"	159
15 1/8	64	4 1/4"	29
			466 Bd. Ft.

YIELD

Percent of input yielded = 94.2% = $\frac{466 \text{ bd. ft.}}{495 \text{ bd. ft.}} \times 100$

RIP

Length	Width of Panel	Pieces (panels)	Bd. Ft.
29	10 1/4	96	198
18	10 1/4	112	144
15 1/8	10 1/4	19	21
			363 Bd.Ft.

YIELD

Percent of input yielded = $\frac{363 \text{ bd. ft.}}{495 \text{ bd. ft.}} \times 100 = 73.36\%$

CUT BACK SALVAGED

Length	Width	Pieces (panels)	Bd. Ft.
15	10 1/4	19	20

OUTPUT — 383 Bd.Ft. Total

TOTAL YIELD

$$\frac{383 \text{ Bd. Ft.}}{495 \text{ Bd. Ft.}} \times 100 = 77.4\%$$

****

COSTS

Normal Drawer Side Material — 4/4, #1 Common and better, green oak

$244 MBF

Cost calculated as follows: #1 Common and better includes:

50% FAS @ $274/MBF	= $137
20% SEL @ $264/MBF	= $ 53
25% #1C @ $189/MBF	= $ 47
5% #2C @ $130/MBF	= $ 7
	$244

Standard yield at rough mill = 55% $\frac{\$244}{55\%}$ = $443.64 MBF actual cost without kiln drying.

Pallet Deckboards - an alternative drawer side material 3/4, green oak, clear $200 MBF delivered $\frac{\$200}{77.4\%}$ = $258.40 MBF actual cost without kiln drying.

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 1

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES		TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
11/11/74	Cornell	3/16	4-sided	1/2"	P/T	1.82	561.43	308.48	102.62	83.55	45.91	15.30	14.88	340.99	187.36	62.45	60.74	39.26
			Oak		Lap	5.10		110.08	36.69		16.38	5.46			66.87	22.29		
8/21/74	Cornell	3/16	4-sided	1/2"	P/T	1.95	416.74	213.71	53.43	39.34	20.17	5.04	9.44	292.90	150.21	51.55	70.28	29.72
			Aspen		Lap	2.75		151.54	37.89		14.31	3.58			106.51	26.63		
8/29/74	Cornell	3/16	4-sided	1/2"	P/T	1.98	397.07	197.51	98.76	46.19	23.23	11.66	11.81	308.93	145.03	78.01	79.00	21.00
			Aspen		Lap	2.90		134.85	67.43		15.93	7.96			106.53	53.26		
9/3/74	Cornell	3/16	4-sided	1/2"	P/T	1.02	71.16	69.76	23.25	17.17	16.83	5.61	24.13	61.24	60.04	20.01	86.06	13. 4
			Mixed		Lap	1.17		60.82	20.27		14.68	4.89			52.34	17.45		
9/3/74	Cornell	3/16	4-sided	1/2"	P/T	2.51	333.84	133.00	44.33	60.25	24.00	8.00	18.05	246.65	98.27	32.76	73.88	26.12
			Mixed		Lap	4.50		74.18	24.73		18.88	6.29			54.81	14.70		
TOTAL					P/T	9.28	1,774.24							1,259.71			70.49	29.51
					Lap	16.42												
AVG.								184.49	64.48				15.66		130.38	46.16		
STD.DEV.								89.74	34.85				5.74		50.69	23.54		
TOTAL					P/T	13.05	Down											
					Lap	22.72	42.6											
11/11-12	Cornell	3/16	4-sided	3/4"	P/T	1.40	218.28	155.91	51.97	18.02	12.87	4.29	8.26	150.32	107.37	35.79	68.87	31.13
			Oak		Lap	2.30		94.90	31.63		7.83	2.61			65.36	21.79		
11/17/75	Cornell	3/16	4-sided	7/8"	P/T	2.37	485.90	205.02	68.34	58.67	24.76	8.25	12.07	326.10	137.60	95.87	67.11	32.89
	Gang Rip	Carb.	Oak		Lap	4.00		121.48	40.49		14.67	4.89			81.53	27.18		

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 2

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.- HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.- HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
1/17/75	Hill	.148	4-sided	3/4"	P/T 0.98	217.74	222.18	74.06	81.70	83.37	27.79	37.52	164.08	167.43	55.81	60.62	39.38
		5/32	Oak	Deckbds.	Lap 8.00		27.22	9.07		10.21	3.40			20.51	6.84		
11/04/74			4-sided		P/T 0.92	263.69	286.62	95.54	21.77	23.66	7.89	8.26	193.36	210.17	70.06	73.33	26.67
			Aspen		Lap 2.17		121.52	40.51		10.03	3.34			89.11	29.70		
12/16-20			4-sided		P/T 1.58	254.92	161.34	53.78	5.97	3.78	1.26	2.34	165.36	104.66	34.89	64.87	35.13
			Mixed		Lap 3.69		69.08	23.02		1.62	.54			44.81	14.94		
			4-sided		P/T .60	87.67	146.12	36.53	14.43	24.05	6.01	16.46	61.25	102.08	25.52	69.86	30.14
			Mixed		Lap 1.44		60.88	15.22		10.02	2.50			42.53	10.63		
			4-sided		P/T 3.71	561.93	151.46	50.49	47.20	12.72	4.24	8.40	347.53	93.67	31.22	61.85	38.15
			Oak		Lap 8.00		70.24	23.41		5.90	1.97			43.44	14.48		
TOTALS					P/T 7.79	1,385.95							931.58			67.22	32.78
					Lap 23.30												
MEAN							193.54	62.08				14.60		135.60	43.50		
STD.DEV.							60.29	23.02						51.02	18.74		
TOTAL					P/T 9.62	Down											
					Lap 27.05	64.4%											
8/27-29	Hill	.148	4-sided	7/8"	P/T	140.78	312.84	104.28	16.87	37.49	12.50	11.98	111.37	247.49	82.50	79.11	20.89
		5/32	Oak	Deckbds.	Lap		80.45	26.82		9.64	3.21			63.64	21.21		
9/3/6			4-sided	1/2"	P/T	188.59	136.66	45.55	27.39	19.85	6.61	14.52	157.55	114.17	38.06	83.54	16.46
			Oak	(15/32)	Lap		94.30	31.43		13.69	4.56			78.77	26.26		

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 3

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
9/16-18	HERMANCE	17/64	3-sided	3/4"	P/T 4.17	566.65	135.89	67.94	32.41**	7.77	3.89	11.71	231.80	55.59	27.79	40.91	59.09
			Mixed	Deckbds.	Lap 8.00		70.83	35.42		4.05	2.06			28.98	14.49		
9/10-12					P/T 1.16	213.40	183.97	91.99	2.60**	2.24	1.12	2.65	101.65	87.63	43.82	47.63	52.37
					Lap 3.26		65.46	32.73		.80	.40			31.18	15.59		
8/27-29				(1/16)	P/T 1.17	201.29	172.04	86.02	8.17	6.98	3.49	4.01	124.97	106.81	53.41	62.09	28.91
					Lap 2.00		100.64	50.32		4.04	2.02			62.48	31.24		
12/16-20					P/T 0												
					Lap 8.00												
TOTAL					P/T 6.50	981.34							458.42			46.71	53.29
					Lap 21.26												
MEAN							163.97	81.98				6.12		83.34	41.67		
STD.DEV.							25.04	12.52						25.88	12.94		
							122.98*	61.49*									
9/10-12				3/8"	P/T 3.51	160.95	45.85	18.34	12.82	3.65	1.46	7.96	72.22	20.58	8.23	44.87	55.13
					Lap 4.74		33.96	13.58		2.71	1.08			15.24	6.10		
							34.39*	13.76*									
TOTAL					P/T 10.01	Down											
					Lap 26.00	61.5%											
9/16-18	BOLTER	1/4"	3-sided	3/4"	P/T 1.35	62.57	46.35	46.35	2.51	1.86	1.86	4.01	25.21	18.67	18.67	40.29	59.71
		(17/	Mixed	Deckbds.	Lap 2.10		29.80	29.80		1.20	1.20			12.00	12.00		
8/21-23		64)		(11/16)	P/T 1.87	110.65	59.17	59.17	7.20	3.85	3.85	6.51	45.62	24.40	24.40	41.23	58.77
					Lap 3.75		29.51	29.51		1.92	1.92			12.17	12.17		
12/16-20					P/T 0												
					Lap 8.00												

* = values less 25% ** = not all input graded

APPENDIX I. MILL NUMBER 3 (Cont'd.)

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.- HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.- HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
TOTAL					P/T 3.22 Lap 13.85	173.22							70.83				
MEAN STD.DEV.							52.76 9.07 39.57*	52.76 9.07 39.57*				5.26		21.54 4.05	21.54 4.05	40.89	59.11
9/10-12			3-sided Mixed	7/16	P/T 0.70 Lap 1.26	58.66	83.80 46.56 62.85*	83.80 46.56 62.85*	10.80	15.43 8.57	15.43 8.57	18.41	31.34	44.77 24.87	44.77 24.87	53.44	46.56
9/16-18	BOLTER	1/4" (17/ 64)	3-sided Mixed	1 9/16" Runners	P/T 1.71 Lap 2.65	155.78	91.10 58.79	91.10 58.79	9.63	5.63 3.63	5.63 3.63	6.18	54.39	31.81 20.53	31.81 20.53	34.91	65.09
8/27-29				1 1/2"	P/T 1.11 Lap 1.81	64.09	57.74 35.41	57.74 35.41	8.03	7.23 4.44	7.23 4.44	12.53	32.21	29.02 17.80	29.02 17.80	50.25	49.75
TOTAL					P/T 2.82 Lap 4.46	219.87							86.60				
MEAN STD.DEV.							74.42 23.59 54.32***	74.42 23.59 54.32***				8.86		30.42 1.97	30.42 1.97	39.39	60.61
9/10-12				1 7/8" Runners	P/T 1.57 Lap 1.94	68.89	48.88 35.51 32.91*	48.88 35.51 32.91*	1.85	1.18 .95	1.18 .95	2.69	50.13	31.93 25.84	31.93 25.84	72.77	27.23
TOTALS					P/T 8.31 Lap 21.51	Down 61.4%											

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 4

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.- HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.- HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
12/16-20	BOLTER	1/4	4-sided		P/T 0												
	+	each	ASPEN		Lap 8.00												
8/21-23	RESAW			1/2"	P/T 2.15	218.99	101.86	25.46	35.12	16.34	4.08	16.00	99.13	46.11	11.53	45.26	54.74
				Deckbds.	Lap 2.83		77.38	19.35		12.40	3.10			35.03	8.76		
8/27-29					P/T 0												
					Lap 3.50												
9/10-12					P/T 0												
					Lap 7.50												
9/18/74				1/2"	P/T 2.19	321.46	146.79	36.70	87.33*	39.88	9.97	29.93	179.79	82.10	20.52	55.93	44.07
					Lap 2.50		128.58	32.15		34.93	8.73			71.92	17.98		
TOTAL					P/T 4.34	540.55							278.92				
					Lap 24.33												
MEAN							124.33	31.08				22.97		64.11	16.03	51.60	48.40
STD.DEV.							31.77	7.95						25.45	6.36		
9/18/74	BOLTER	1/4	3-sided	1 1/2"	P/T 2.22	450.94	203.13	50.78	108.88	49.05	12.26	24.15	263.62	118.75	29.69	58.46	41.54
	+	each	MIXED	Runners	Lap 3.33		135.42	33.85		32.70	8.17			79.17	19.79		
TOTAL	RESAW				P/T 6.56	DOWN 76.3%											
					Lap 27.66												

*Not all input graded

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 5

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
11/18/74	Hill #1	7/32	3-sided Conver-sion to 4-sided Oak	1/2"	P/T 1.20	181.41	151.18	50.39	4.96	4.31	1.37	2.73	43.27	36.06	12.02	23.85	76.15
					Lap 1.50		120.94	40.31		3.31	1.10			28.85	9.62		
12/19/75	Hill #1	.210 ±.002	Oak	3/4"	P/T 3.37	442.31	131.13	65.57	44.98	13.34	6.67	10.17	238.08	70.58	35.29	53.83	46.17
					Lap 4.75		93.12	47.56		9.47	4.74			50.12	25.06		
	Hill #2	.210 ±.002	Oak	3/4"	P/T 1.47	138.39	94.14	31.38	22.79	15.50	5.17	19.70	89.85	61.12	20.37	64.93	35.07
					Lap 2.00		69.20	23.07		11.36	3.79			44.92	14.97		
1/18/75	Hill #1		Oak	1 3/4"	P/T 1.85	193.30	104.49	34.83	12.76	6.90	2.30	7.02	126.84	68.56	22.85	65.62	34.38
					Lap 2.28		84.78	28.26		5.60	1.87			55.63	18.54		
TOTAL	3/4"			3/4"	P/T 4.84	580.70							327.93			56.47	43.53
					Lap 6.75												
AVG.	3/4"			3/4"	P/T		112.64	48.48				14.94		65.85	27.83		
STD.DEV.	3/4"			3/4"	P/T		26.16	24.18				6.74		6.69	10.55		
	Hill #1				P/T 0												
					Lap 2.00												
1/22/75	Hill #1				P/T 0												
					Lap 1.00												
11/18/74	Hill #2				P/T 0												
					Lap 6.00												
2/19/75	Hill #2			7/8"	P/T 3.61	406.20	112.61	37.54	117.20	32.47	10.82	28.85	234.37	64.92	21.64	57.70	32.30
			Oak	Oak	Lap 4.75		85.52	28.51		24.67	8.22			49.34	16.45		
TOTALS					P/T 16.34												
					Lap 31.03												
1/22/75	Hill #2	4-sided Oak	7/32	1 1/8"	P/T 1.44	202.60	140.69	46.90	17.60	12.22	4.07	8.69	128.07	88.94	29.65	63.21	36.79
					Lap 2.00		101.30	33.77		8.80	2.93			64.04	21.35		

APPENDIX I. MILL NUMBER 5 (Cont'd.)

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
11/05/74	Hill #2	Oak		1 5/8"	P/T .79	187.81	237.73	79.24	7.27	9.20	3.07	3.87	119.17	150.85	50.28	63.45	36.55
					Lap 1.45		129.52	43.17		5.01	1.67			82.19	27.40		
TOTAL					P/T 18.57	Down											
					Lap 34.48	46.2%											
11/18/74	Alden	7/32	4-sided 80% Maple 20% Oak	1 3/8"	P/T 4.00	554.92	138.73	69.37	71.84	17.96	8.98	12.95	429.47	107.37	53.68	77.39	22.61
					Lap 6.00		92.49	46.24		11.97	5.99			71.58	35.79		
					P/T 0												
					Lap 2.00												
1/22/75					P/T 0												
					Lap 2.00												
2/19/75					P/T 0												
					Lap 8.00												
					P/T 4.00	Down											
					Lap 18.00	77.8%											

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 6

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
1/29/75	HOMEMADE	.135	4-sided	1/2"	P/T 4.02	263.58	65.57	32.78	27.72	6.90	3.45	10.52	214.79	53.43	26.72	81.49	18.51
			Aspen	(7/16)	Lap 8.25		31.95	15.98		3.36	1.68			26.04	13.02		
9/3-6/74					P/T 4.66	432.62	94.05	47.03	71.63	15.57	7.79	16.56	331.22	72.00	36.00	76.56	23.44
					Lap 4.71		91.85	45.93		15.21	7.60			70.32	35.16		
TOTAL					P/T 8.62	696.20							546.01			78.43	21.57
					Lap 12.96												
MEAN							79.81	39.91				13.54		62.72	31.36		
STD.DEV.							20.14	10.08						13.13	6.56		
9/3-6/74			3-sided	1/2"	P/T 2.13	145.11	68.13	34.06	15.03	7.06	3.53	10.36	124.04	58.23	29.12	85.48	14.52
			Aspen		Lap 4.03		36.01	18.01		3.73	1.87			30.78	15.39		
TOTAL					P/T 13.42	Down											
					Lap 20.50	34.5%											
8/21-3/4	HOMEMADE	.135	3-sided	3/4"	P/T 0.51	87.32	171.22	85.61	6.90	13.53	6.76	7.90	68.66	134.63	67.31	78.75	21.25
			Aspen	(11/16)	Lap 0.83		105.21	52.61		8.31	4.16			82.72	41.36		
8/27-9/4				1 5/16"	P/T 2.16	328.87	152.26	76.13	54.24	25.11	12.56	16.49	252.04	116.68	58.34	76.64	23.36
				Deckbds.	Lap 2.68		127.71	61.36		20.29	10.12			94.04	47.02		
9/05/75	Hill	.143	3-sided	3" planks	P/T 1.64	384.51	234.46	117.23	33.26	20.28	10.14	8.65	221.25	134.91	67.46	57.54	42.46
			Asper	for resaw	Lap 8.74		43.99	22.00		3.81	1.91			25.32	12.66		
							175.85*	87.92*									
8/27-9/4		.143	4-sided	3" planks	P/T .76	148.79	195.77	97.88	14.28	18.79	9.39	9.60	103.86	136.66	68.33	69.80	30.20
			Aspen		Lap .92		161.72	80.86		15.52	7.76			112.89	56.45		
TOTAL					P/T 2.40	533.30							325.11			60.96	39.04
					Lap 9.66												
AVG.							185.81	92.90				9.13		135.79	67.90		
							14.09	7.04						1.24	.62		
TOTAL					P/T 2.40	Down											
					Lap 9.66	75.16%											

*Reduced to 4-sided

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 7

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES		TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
9/16-18	Pettit	1/4"	3-sided	1/2" (15/32	P/T	3.38	387.64	114.69	57.34	60.78	17.98	8.99	15.68	206.88	61.19	30.59	53.36	46.64
	Model 300B	In-sert	Mixed	or 7/16)	Lap	4.67		83.01	41.50		13.02	6.51			44.29	22.15		
9/10-12					P/T	4.60	469.68	102.10	51.05	69.07	15.02	7.51	14.70	239.75	52.12	26.06	51.05	48.95
					Lap	7.91		59.38	29.69		8.73	4.37			30.31	15.16		
8/27-29					P/T	1.64	97.54	93.79	46.90	27.71	26.65	13.32	28.41	45.46	43.71	21.85	46.60	53.40
					Lap	1.67		58.41	29.20		16.60	8.30			27.22	13.61		
8/21-23					P/T	2.92	279.67	95.78	47.89	60.38	20.67	10.34	21.59	144.43	49.46	24.73	51.64	48.36
					Lap	4.00		69.92	34.96		15.10	7.55			36.11	18.05		
12/16-20					P/T	1.98	278.72	140.77	70.39	45.05	22.75	11.38	16.16	109.11	55.11	27.56	39.14	60.86
					Lap	4.08		68.31	34.31		11.04	5.52			26.74	13.37		
																	49.27	50.13
TOTAL				Down	P/T	13.92	1,513.25							745.58				
				37.7%	Lap	22.33												
MEAN								109.43	54.71				19.31		52.32	26.16		
STD.DEV.								19.33	9.67						6.50	3.25		

APPENDIX I. DATA TABULATIONS FOR EIGHT PALLET MILLS.

MILL NUMBER 8

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES		TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
8/27-9/4	Hill #2				P/T	0												
					Lap	4.00												
9/3-6/74	Hill #2	1/4	4-sided	3/8"	P/T	2.09	332.11	158.90	52.97	17.28	8.27	2.76	5.20	223.19	106.79	35.60	67.20	32.80
			Aspen	Deckbds.	Lap	3.33		99.73			5.19	1.73			67.02	22.34		
9/12/74	Hill #2	1/4	3-sided	1 5/16"	P/T	2.01	838.88	417.35	139.12	49.35	24.55	8.18	5.88	534.63	265.95	88.66	63.73	36.27
			Mixed	Deckbds.	Lap	3.25		258.12	86.04		15.19	5.06			164.50	54.83		
								313.01*	164.34*									
								Not Inc.							Not	Inc.		
9/12/74	Hill #2	1/4	3-sided	3 1/2"	P/T	.15	147.20	981.33	327.11	26.74	178.27	59.42	18.17	81.34	542.27	180.76	50.26	44.74
			Mixed		Lap	.52		283.08	94.36		51.42	17.14			156.42	52.14		
	Hill #1		Mixed		P/T	2.52	573.93	227.75	113.88					222.53	88.31	44.16	38.77	61.23
					Lap	8.00		71.74	35.87						27.82	13.91		
								170.81*	85.41*									
	Hill #2		4-sided	3 1/2"	P/T	1.17	242.86	205.51	69.19	18.37	15.70	5.23	7.56	133.85	114.40	38.13	55.11	44.89
			Mixed		Lap	1/35		179.90	59.97		13.61	4.54			99.15	33.05		
TOTAL					P/T	3.84	963.99							437.72				
					Lap	9.87											45.41	54.59
MEAN								189.19*	77.30*				12.87		101.36	41.14		
STD.DEV.								25.99*	77.47*						18.45	4.26		
11/4/74	Hill #1	1/4	4-sided	3/4"	P/T	1.17	96.75	82.69	41.35	9.90	8.46	4.23	10.23	67.74	57.90	28.95	70.02	29.98
			Aspen	Deckbds.	Lap	1.25		77.40	38.70		7.92	3.96			54.19	27.09		
8/27-9/4					P/T	0												
					Lap	4.00												
9/3-6/74				1/2"	P/T	2.19	143.84	65.68	43.78					116.14	53.04	35.36	80.74	19.26
				Deckbds.	Lap	2.58		55.75	37.17						45.02	30.01		

*Adjusted to 4-sided

APPENDIX I. MILL NUMBER 8 (Cont'd.)

DATE	MACHINERY	KERF	CANT INPUT	PRODUCT	TIMES	TOTAL INPUT CU. FT.	INPUT/ MACH.-HOUR CU. FT.	INPUT/ MAN-HR. CU. FT.	CLEAR INPUT CU. FT.	CLEAR INPUT/ MACH-HR. CU. FT.	CLEAR INPUT/ MAN-HR. CU. FT.	% CLEAR CANT INPUT	TOTAL OUTPUT CU. FT.	OUTPUT MACH.-HOUR CU. FT.	OUTPUT MAN-HR. CU. FT.	OUTPUT AS A % OF INPUT	% WASTE
TOTAL					P/T 11.78 Lap 29.03	Down 59.5%											
12/18/74	HILL #3	5/32	4-sided Aspen	1.5	P/T 1.30 Lap 2.62	131.22	79.05 64.01	39.52 32.00	3.36	4.12 2.05	2.06 1.06	2.76	95.76	73.66 36.55	36.83 18.28	72.98	27.02
				3.5	P/T 1.66 Lap 2.05	179.53	19.05 87.58	39.52 43.79	46.71	28.14 22.79	14.07 11.39	26.02	131.22	79.05 64.01	39.52 32.00	73.09	26.91
11/4/74	Hill #3	5/32 Car- bide	4-sided Aspen	1/2" Deckbds.	P/T .57 Lap 1.00	45.87	80.47 45.87	40.24 27.94	1.09	1.91 1.09	.96 .53	2.75	25.54	44.81 25.54	22.41 12.77	55.67	44.33
12/18/74					P/T 1.21 Lap 1.83	143.46	118.56 78.89	39.32 26.13	22.13	18.31 12.10	6.10 4.03	15.44	111.16	91.87 60.74	30.62 20.35	77.49	22.51
TOTAL					P/T 1.78 Lap 2.83	189.33							136.70				
MEAN STD.DEV.							99.52 26.94	39.88 .51				9.10		68.34 33.28	26.52 5.81	72.20	27.80
11/4/74				3/4" Deckbds.	P/T .54 Lap 1.00	47.84	88.59 47.84	44.29 23.92	4.84	8.96 4.84	4.48 2.42	10.12	53.56	62.15 33.56	31.08 16.78	70.15	29.85
TOTAL					P/T 11.78 Lap 24.28	Down 51.5%											