The Processing Industry for

Forest Products

in Eastern Oklahoma

by

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Structure, Efficiency, Capacity and Potential Impact on the Rural Economy

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TABLE OF CONTENTS

Summary

Processing of local forest products is an important industry in Eastern Oklahoma. Affording employment for nearly 1600 people, and a market for five million dollars of unprocessed wood annually, the industry is a vital segment of the local economy. It is especially important as a source of income to farmers and other small operators in an area where income per capita is below the state average.

This report describes the industry in 1956. Great variations in efficiency among local sawmills were found. Sawmills in the area were operating at less than economic capacity.

Efficient year-round use of existing plant and equipment could increase total output of product by 70 percent. With minimum changes in equipment and location, 80 of the present 133 sawmills, operating at capacity, could double the present output. Sawmill output would then meet the estimated 1975 requirements for the area.

Acknowledgments

The authors wish to acknowledge the help they received in performing this research. The Oklahoma Extension Service—especially Mr. C. L. Clymer, Extension Forester—aided in formulating the problem and obtaining the factual results. Local workers in the offices of the County Agents and of the Soil Conservation Service interviewed most of the firms in the forest industry. In the Department of Agricultural Economics, G. G. Judge, W. B. Back, and T. D. Wallace generously lent their efforts to improve the analytical content of the study.

The majority of the data and part of the analysis found in this report was taken from the senior authors masters thesis titled, "Marketing of Farm Woodlot Products in Eastern Oklahoma, May, 1958, Oklahoma State University. More complete data can be found therein.

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The Processing Industry For Forest Products in Eastern Oklahoma

Structure, Efficiency, Capacity and Potential Impact on the Rural Economy

By Robert Raunikar and E. J. R. Booth[1]
Department of Agricultural Economics

INTRODUCTION

The study reported in this bulletin had two main purposes:

(1) To describe and analyze the existing structure of the processing industry for forest products in Eastern Oklahoma.

(2) To estimate the efficiency and capacity of local sawmills.

The majority of Oklahoma's forest resources are concentrated in the eastern area of the state where farm incomes are lowest. Farmers own 31 percent of the area's privately owned forest land. The results of the study were incidentally useful in evaluating the impact of potential changes in the wood processing industry on the rural economy.

Present Knowledge

Products of Oklahoma's wood-using industries were valued in excess of $50 million in 1956.[2] Approximately five thousand persons in 445 establishments, including 297 sawmills, were paid annually nearly $17 million in wages during that year.

There has been no published research on local sawmill efficiency or capacity, although a theoretical framework can be found in Professor Worrell's recent textbook.[3]

The remainder of the literature reviewed emphasized the marketing practices of forest processing firms, but provided useful information on methods for collecting data.[4]

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[1] Mr. Raunikar is at present a research assistant at North Carolina State University.

[2] "Oklahoma Forest Facts," 1956 edition, published by American Forest Products, Inc., Washington,

[3] A. C. Worrell, *The Economics of American Forestry,* (New York: Wiley and Sons, Inc.) 1959. This book was received too late to be of use in the analysis.

[4] J. Harry Rich and George H. Sisterhenm, "Marketing Forest Products in Massachusetts," *Massachusetts Agr. Expt. Sta., Bul. 492,* University of Massachusetts, 1955.

Gregory Baker and Frank E. Beyer, "Marketing Forest Products for Small Woodland Areas in Maine," *Maine Agr. Expt. Sta., Bul. 554,* University of Maine, December 1956.

Louis C. Swain and Oliver F. Wallace, "Marketing Forest Products in New Hampshire," *New Hampshire Agr. Expt. Sta., Bul. 420,* University of New Hampshire, June 1955.

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Northeastern Regional Technical Committee, "Marketing Forest Products from Small Woodland Areas in the Northeast," Northeast Regional Publication No. 25, *Vermont Agr. Expt. Sta., Bul. 595,* Burlington, Vermont, June 1956.

Methods

Fifteen counties—Adair, Atoka, Cherokee, Choctaw, Coal, Delaware, Haskell, Latimer, LeFlore, McCurtain, McIntosh, Muskogee, Pittsburg, Pushmataha, and Sequoyah—were selected for study, since the major forest resources of Oklahoma occur in this area. These counties have been included in previous forest resource studies, and thus provide a basis for comparison.

A list was compiled of all firms in the industry through cooperation of local workers in the Extension Service, the Soil Conservation Service, the Forestry Service, officers of local chambers of commerce, and individuals in the forest industry. Schedules were then designed to obtain the information from three major classes of firms: sawmills, piece-wood buyers, and miscellaneous outlets. Local workers of the Extension Service, the Soil Conservation Service, and the Forestry Service aided in interviewing the firms' owners or operators. The interviewing was done during the summer of 1957, and the data covered the operations of the firms in 1956.

A directory, compiled from this list of firms, was published by the Extension Service of the Oklahoma State University as Circular 663, "Directory of Wood Industries in Eastern Oklahoma."

The study of efficiency and capacity was restricted to sawmills since the outlet for local forest products is mainly confined to them. Sawmill firms were grouped by type of fixed plant and examined for efficiency of operation with respect to variable inputs.

OKLAHOMA'S FOREST RESOURCES

Importance

The 1955 net growth of timber in fifteen counties of Eastern Oklahoma was 107 million cubic feet, including 245 million board feet of sawtimber.[5]. Less than one half of this net growth, 115 million board feet, was removed in 1955. The Forest Service states that, under the application of minimum improved forestry practices, the annual growth in Eastern Oklahoma could be doubled.

The total work force in these fifteen counties declined from 124,000 to 95,000 workers during the period 1929-1949, with the forest work force decreasing from 4,974 to 4,398 workers. Thus, the forest work force declined by 11.6 percent during the period, while total employment in the area decreased by 23.3 percent.

Location

Figure 1 illustrates the location of the important species of wood in Eastern Oklahoma. The major pine resources are located in four

[5] U. S. Department of Agriculture Forest Service, *Timber Resources Review*, Chapter 9, Washington, D. C., September 1955.

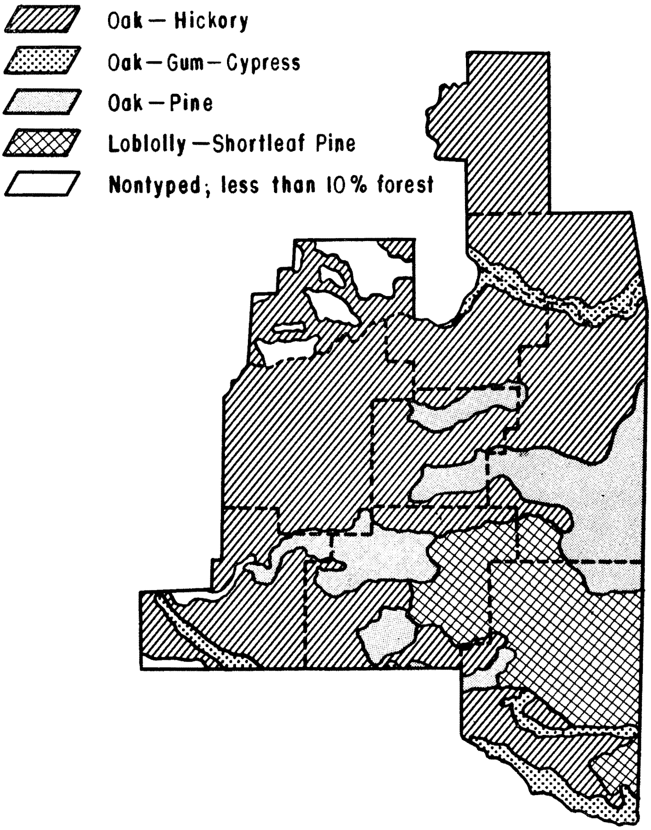

Fig. 1 Major wood species in Eastern Oklahoma.

counties. Hardwoods are the primary timber species outside of the Southeast section of the state.[6]

In 1953, 88.5 percent of the privately owned forest land in the state was situated in this fifteen-county area (Table 1). There was a decrease in large-diameter volume and an increase in middle- and small diameter volume of timber in five counties—Haskell, Latimer, LeFlore, McCurtain, and Pushmataha—from 1936 to 1956.[7] As a net effect, about the same total volume of sawtimber existed in the area in 1956 as in 1936. The trend there toward larger numbers of smaller softwood trees is probably consistent with trends in the rest of the fifteen counties.

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[6] The term "hardwood" is used in this study to mean all species other than pine.
[7] Phillip A. Wheeler, "Forests of East Oklahoma," *Forest Survey Release No.* 79, U. S. Department of Agriculture, Southern Forest Expt. Sta., New Orleans, La., June 1957.

Table 1. The Location of Privately Owned Commercial Forest Land in Oklahoma, 1953

AREA	ACREAGE million acres			DISTRIBUTION percent		
	Farm	Other	Total	Farm	Other	Total
Fifteen-County Area	1.70	3.21	4.91	30.7	57.8	88.5
Other sixty-two Counties	0.54	0 10	0.64	9.7	1.8	11.5
State	2.24	3.31	5.55	40.4	59.6	100.0

SOURCE: U. S. Department of Agriculture Forest Service, "Timber Resource Review," Chapter 9, Washington, D. C., September 1955.

Ownership

Table 1 also illustrates the distribution of ownership of the privately owned commercial forest land in Oklahoma in 1953. One and seventenths million acres of the total 4.9 million acres in the area was owned by farmers. Woodland not pastured comprises from 2 to 13 percent of all farm land, and all farm woodland from 12 to 67 percent. For the area as a whole, the averages are 4 and 41 percent, respectively. Thus, farmers own a large share of the forest land, and farm forest land comprises a large part of all farm land. Farm owners in Eastern Oklahoma more than doubled their acreage of woodland from 812,000 to 1,700,000 acres between 1945 and 1953. By 1953, farmers owned 31 percent of the privately owned commercial forest in the fifteen-county area. The pine counties previously mentioned contained the highest proportion of non-farm privately owned commercial forest.

THE RURAL ECONOMY

Coincident with the high concentration of forest resources in the Eastern area of Oklahoma and the high proportion of this land owned by farmers, there is a high degree of serious low-income farming. Figure 2, when combined with Figure 1, illustrates this coincidence. Table 2 additionally shows the importance of forest products to local farming.

Farm products with a local resource advantage, such as timber in Eastern Oklahoma, have a potential for initiating income-raising changes in a low-income farm area. In an unpublished report of the sub-committee on Low Income Rural Areas to the Social Science Research Council, Dr. Nicholls states that this potential may be reinforced or restricted by the structure of the local markets for the crop. Increased farm production necessarily involves certain concomitant change in marketing institutions, facilities, services, and practices. This study assessed the ability of the processing industry to adjust its structure, efficiency, and especially, capacity to the potential increased supplies of local timber, much of which could come from farm woodlots.

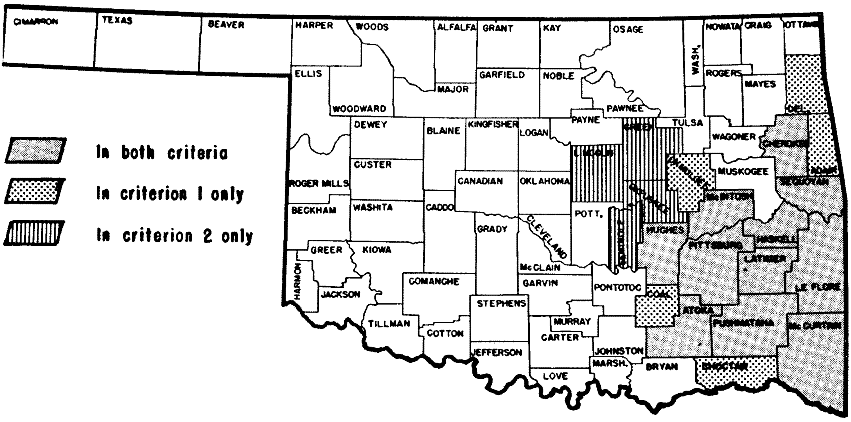

Fig. 2 Counties with lowest farm income and levels of living, 1954, USDA, ARS and AMS.

Criterion 1. Lowest 500 U.S. counties ranked by level-of-living of farm families.

Criterion 2. 500 U.S. counties with largest proportion of commercial farms having sales of farm products valued at less than $2,500.

Table 2. The Distribution of Land, Farm Forest Land, Value of Farm Forest Products and Gross Farm Income by 15 Counties in 1954.

COUNTY	Total Land Area	Proportion of Land in Farms	PROPORTION FARM LAND Woodland not Pastured	All Woodland	Value of Forest Products Sold per Farm Reporting	Median Value of all Products Sold per Farm
	thousand acres	*percent*	*percent*	*percent*	*dollars*	*dollars*
Adair	364	52	14	49	152	455
Atoka	635	63	2	52	447	445
Cherokee	500	46	13	46	153	397
Choctaw	502	67	2	45	164	635
Coal	337	80	2	35	164	958
Delaware	461	59	6	47	109	663
Haskell	393	75	2	35	98	678
Latimer	472	48	2	54	130	549
LeFlore	1,008	39	4	38	219	369
McCurtain	1,187	31	6	48	233	310
McIntosh	458	73	2	24	196	877
Muskogee	525	70	2	12	107	786
Pittsburg	870	67	2	41	122	637
Pushmataha	911	36	2	67	331	653
Sequoyah	450	56	4	34	125	231
AREA	9,072	53	4	41	201	576

SOURCE: U. S. Department of Commerce, *U. S. Census of Agriculture*, 1954.

STRUCTURE OF THE INDUSTRY

The Whole Industry

Value of industry production by counties

Table 3 presents the value of forest products by counties, using census data and the results from the study. Double counting naturally creeps into some of these figures due to wood passing from one firm to another. An attempt was made to eliminate this double counting in calculating the 1956 estimated gross value of farm production.

The total gross value figure of $4,146,000 overestimates, of course, the contribution of forest industries to local income. Nevertheless, the distribution by counties of this total figure is of interest. There are seven counties producing more than $200,000 of value, and these seven counties contribute 95 percent of the total gross value.

The census data show a large amount of variability in gross value between counties and between years. In 1956, only five of the fifteen counties lay within the 1929-54 average deviation range. All but one of the other counties lay above the range.

Pine contributed more to the value of farm forest products than hardwood, and contributed 75 percent of the total industry value.

It must be remembered that the 1956 figures were obtained from the processing industries. Some counties, such as Choctaw, have depleted their timber resources considerably and the local forest industries obtain the majority of their timber from outside the county.

In the fifteen-county area, the 1956 estimated gross value of farm forest products was $859,254. This amount is considerably greater than that reported by the census of 1954. This wood of farm-owned origin contributed another half million dollars of gross value when further processing had been accomplished, as indicated by the value attributed to "agribusiness" of $1,347,560.

Product volumes and values of the primary industries

The volume and value of forest products processed in the fifteen counties were classified by eight "primary" industries as shown in Table 4. It will be seen that sawmills and creosoting plants contribute most to the industry and to the farm value; but if the pulp, pole, post and tie buyers are put together, the three types of firms each have values evenly divided at just over 30 percent of the total. A major part (82 percent) of the wood volume cut in Eastern Oklahoma was pine. Only three types of industries use less than 70 percent pine. In all but two cases, pine contributes greater value than volume. These two exceptions are the props and posts buyers and tie buyers, where hardwood has a higher value for its particular use than pine. None of the four tie buyers bought wood directly from farmers; but, since they and the charcoal wood and handle stock buyers concentrate on hardwood, and

Table 3. Census Value of Farm Forest Sales and Survey Stump Value of Forest Industry Production, by Counties

COUNTY	U. S. CENSUS			VALUE OF INDUSTRY PRODUCTION					
	Farm Sales			Farm		Agri-Business		Total	
	1949[1] Gross Value	1954[1] Gross Value	1929-1954[1] A.D. Range[2]	1956 Gross Value[3]	1956 Pine	1956 Gross Value[4]	1956 Pine	1956 Gross Value[5]	1956 Pine
	dollars	*dollars*	*dollars*	*dollars*	*percent*	*dollars*	*percent*	*dollars*	*percent*
Adair	13,952	13,225	9,000-47,000	74,105	23	204,105	8	204,105	8
Atoka	18,735	14,361	7,000-19,000	67,628	35	67,628	35	67,988	35
Cherokee	23,670	10,985	14,000-40,000	6,816	3	6,816	3	11,552	6
Choctaw	34,919	7,053	8,000-30,000	287,330	98	523,016	54	580,267	58
Coal	11,697	3,609	1,000-13,000	6,959	2	6,959	2	6,959	2
Delaware	24,618	7,869	8,000-52,000	104,448	1	104,448	1	105,730	2
Haskell	7,433	1,377	1,000- 5,000	2,455	36	2,455	36	5,753	64
Latimer	7,073	3,626	2,000- 6,000	5,890	96	5,890	96	63,086	86
LeFlore	45,343	20,140	11,000-33,000	65,409	99	115,535	99	803,798	99
McCurtain	45,988	35,653	26,000-52,000	91,847	87	163,947	49	1,526,454	76
McIntosh	3,336	4,315	2,000- 8,000	7,563	0	7,563	0	7,603	0
Muskogee	5,429	1,501	2,000- 6,000	3,410	0	3,410	0	3,450	0
Pittsburg	9,546	2,935	1,000-15,000	17,305	37	17,305	37	28,215	28
Pushmataha	17,823	26,151	11,000-25,000	36,946	39	36,946	39	200,705	87
Sequoyah	3,688	1,873	1,000-19,000	81,143	95	81,537	95	530,379	97
AREA	273,250	154,673	120,000-340,000	859,254	72	1,347,560	46	4,146,044	75

[1] Source: U. S. Department of Commerce. Bureau of Census, *U. S. Census of Agriculture,* 1935, 1945, 1954, (Washington, D. C., 1949, 1954).

[2] For normal or moderately skewed distribution $P(|X-\bar{X}| \leq A.D.) = .575$, where A.D. (average deviation) $= (\sum|X|) \div N$.

[3] Excludes value of ties bought by tie yards and creosoting plants, to eliminate double-counting.

[4] Includes value of all forest products of farm origin bought by the industries.

[5] Includes value of all forest products of farm and non-farm origin bought by the industries.

Table 4. Volume and Value of Non-Farm and Farm Wood by Types and Numbers of Primary Industries

INDUSTRY		VOLUME		INDUSTRY VALUE			FARM VALUE	
Class	Number[1]	Amount and Unit	Percent Pine	Total	Percent Pine	Percent of Total Value	Estimated Total	Percent of Industry Value
				(dollars)			*(dollars)*	
Sawmills	124	78.865 M.B.F.	72	1,387,219	88	33	235,692	17
Pulp Buyers	12	37,540 units	81	411,750	88	10	96,998	24
Pole Buyers	3	56,000 pieces	100	71,150	100	2	375	1
Props and Posts Buyers	29	2,384,000 pieces	76	310,640	63	7	79,905	26
Tie Buyers	4	425,000 pieces	24	496,200	20	12	------	--
Charcoal Wood Buyers	4	2,550 cords	0	22,800	0	1	21,000	92
Handle Stock Buyers	3	1,850 cords	0	36.750	0	1	36,750	100
Creosoting Plants	5	3.699,620 cu. ft.	82	1,409,535	82	34	388,534	28
TOTALS	169			4,146,044		100	859,254	21

[1] Numbers in this column do not sum to the total since some establishments buy more than one form of wood.

the farm-owned commercial land has a greater proportion of hardwood than the non-farm commercial land, it may become important for the rural economy to develop these industries further.

Of the total income from forest products, 75 percent is attributable to pine; and one fifth of this total value goes to the farm owners of timber resources.

Sawmills are by far the largest single group in numbers, but many of these firms are quite small. In total, however, they handle 33 percent of the total gross value in the industry and provide sawn wood for tie buyers and creosoting plants. They also contribute semi-finished wood to the secondary wood users.

Product volumes and values of the secondary wood users

Table 5 shows the amount of wood bought in a semi-finished form by specified industries. Some secondary woodusers were omitted from the study, but those interviewed indicate the importance of this group as indirect outlets for wood, since their capacity limits, to some extent, the volume of wood products processed by the primary industries.

The twelve planing mills in the area, some of which are run in conjunction with the sawmills, plane 28 percent of the total volume sawn. The secondary wood users process roughly 30 percent of the sawmill volume in the area.[8]

Industry Work Force

Table 6 gives a breakdown of the work force employed by each type of firms in the primary industry. Sixty-seven and one-half percent of the man days worked in the industry are worked in sawmills. However, as will be seen later, more than 250 sawmill workers are employed only seasonally. The total of 257,000 man days in the industry means at least that there is an equivalent of about 1,000 year-round jobs for workers in the area. Not included in the table are 322 full-time jobs in the secondary industries, 144 jobs in forest industries not using local wood, and 5 sawmills for which the work force was not reported. Other important sectors were not covered such as wood cutters, haulers, jobbers and retail lumber dealers.

Table 5. Volume and Value of Secondary Wood-Users[1]

Industry	Number	Volume (M Bd. Ft.)	Value (dollars)
Planing Mills	12	21,949	554,730[2]
Furniture Factories	4	1,664	68,800
Handle and Gunstock Mills	2	100[3]	4,000[3]
TOTAL	18	23,713	627,530

[1] Secondary wood-users are defined as those industries who buy semi-finished wood.
[2] Value not available for four mills.
[3] Incomplete information.

[8] Wood sawn or planed in a county does not necessarily come from within that county, or even the state; but it seems reasonable to assume that for a specific county the imports will balance out.

Table 6. Industry Work Force (Primary)

INDUSTRIES	MAN DAYS Number	MAN DAYS Percent	WORKERS Number	WORKERS Percent
Sawmills	168,740	65.7	871	69.2
Piece-wood buyers	40,850	15.9	173	13 7
Charcoal Wood Buyers	1,650	.6	28	2.2
Handle Stock Buyers	5,740	2.2	24	1.9
Creosoting Plants	39,760	15.6	163	13.0
TOTAL	256,740	100.0	1,259	100.0

Sawmills

Sawmills, the largest single class of firms in the processing industry, are constantly changing in number. At the time of the survey, 133 sawmills were contacted in the 15-county area. Of this total, 35 percent were portable. In addition, many of the sawmills go completely in or out of business each year. Forty-one sawmills were known to have gone out of business or moved out of the area since 1948.

Duration of establishment—The date of establishment gives some clues to the possible permanency of the sawmill industry. In the survey, 132 sawmills reported their date of establishment. Seven sawmills (5 percent) were established during 1956 and 1957; 57 percent were established since 1950; and 34 percent had been established less than four years. Nearly three-fourths of the sawmills had been put into operation during the preceding ten years. Figure (3) shows the large proportion of

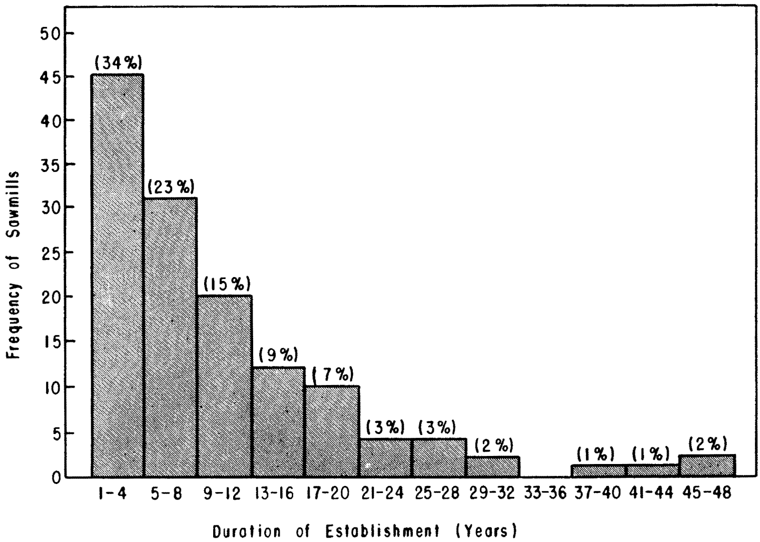

Fig. 3 Distribution of sawmills by duration of establishment at time of survey (1957).

"young" sawmills. Those established for more than ten years are generally of a stationary type and have more nearly the maximum output for the type of equipment used. These mills are more often located in the pine counties.

Of the total number of mills for which complete data are available, 41 percent were established during the period 1953 to 1957, and about 51 percent are classed as stationary. During the period 1948 to 1952, 21 percent of the mills were established, and nearly three fourths of these were stationary. Thirty-eight percent of all mills established before 1947, and 81 percent of those established before 1943, are stationary.

Work force

Figure 4 shows the distribution of the work force in the sawmill industry as reported by 129 mills. Seventy-four percent employed three men or less, the most usual number being two.

The number of workers used by the mills is not wholly dependent on the type of equipment used. Mills with only one head saw may be employing from one to five men when three men might be sufficient for the mill operation itself. But many large mills employed men for wood producing and hauling work. Other mills, using two men or less, are operated only for supplementary income. The under-manned mills, especially, operated only very short periods during the year.

Many mill operators gave unavailability of timber as the main reason for not increasing their output.

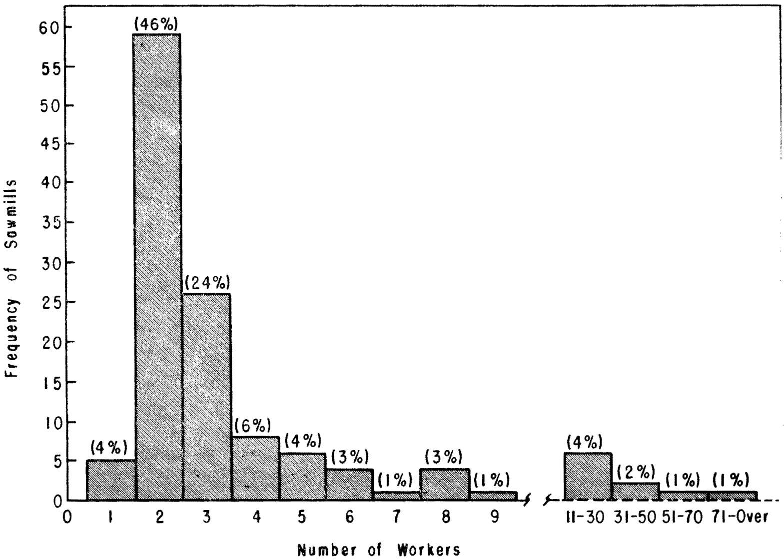

Fig. 4 Distribution of sawmills by usual number of workers.

Types of product

The three major classes of products sawn are ties, bridging, and construction lumber. All but 5 percent of the 132 mills reporting produced at least one of these three products. Fifty-eight percent produced construction lumber, 24 percent ties, and 13 percent bridging. Ties and bridging are mainly hardwood, thus are produced primarily outside the pine counties.

Very few sawmills specialize in one product. Ninety-one of the firms reporting indicated they produced at least two commodities, with 31 producing three or more. Diversification of products by these sawmills is dependent on the species of wood in the locality, its size, its availability, and the secondary wood-using market it faces.

Saw logs sizes

As has been noted in previous studies, the size of logs sawn by mills in Eastern Oklahoma is decreasing. Figure 5 illustrates the average small-end diameter of logs, both pine and hardwood. Nearly half of the 55 mills sawing pine were sawing pine logs with an average diameter of eight to nine inches, and one-third were sawing a ten- to eleven-inch log. Mills sawing small diameter pine logs were usually located outside the predominantly pine counties.

Many mills were sawing some large sized logs, but with most mills averaging eleven inches or less for the pine logs, the processing efficiency is obviously hampered.

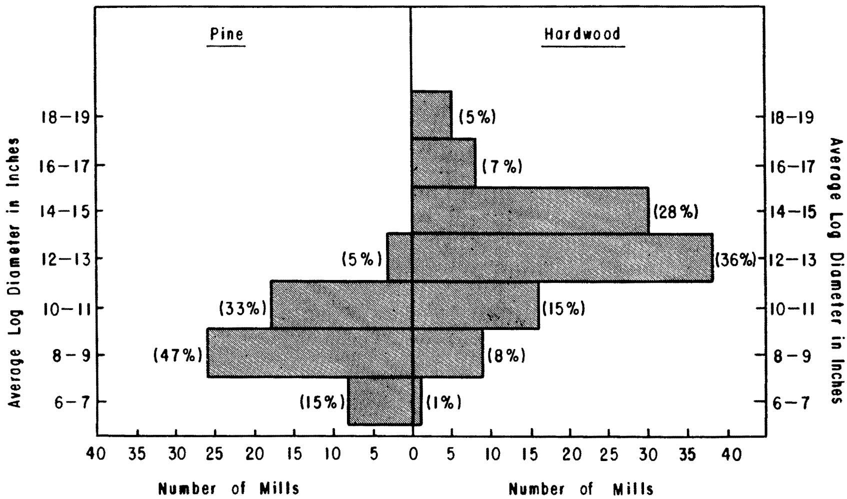

Fig. 5 Distribution of sawmills by average small-end diameter of logs sawed.

The 107 mills sawing hardwood are sawing larger logs than those sawing pine. Nearly two thirds of the mills are sawing logs with average small-end diameters between twelve and fifteen inches. The difference in size of logs between pine and hardwood may be in part attributed to the difference in value of these products. At the stump, the price per thousand board feet of pine is about $10 higher than that of hardwood, since pine, as an end product, is easier to move.

Many larger mills, particularly in the pine region, are moving toward selective cutting of timber to improve the size and quality of the timber and the efficiency of the mills.

Length of haul

The distance logs must be hauled from the stump to the saw can become a major item of marketing cost. A distribution of the length of haul is shown in Figure 6. Eighty-three percent of the 127 mills reporting hauled an average of 15 miles or less one way, with 3 percent of the mills traveling more than 25 miles to obtain timber. Over one

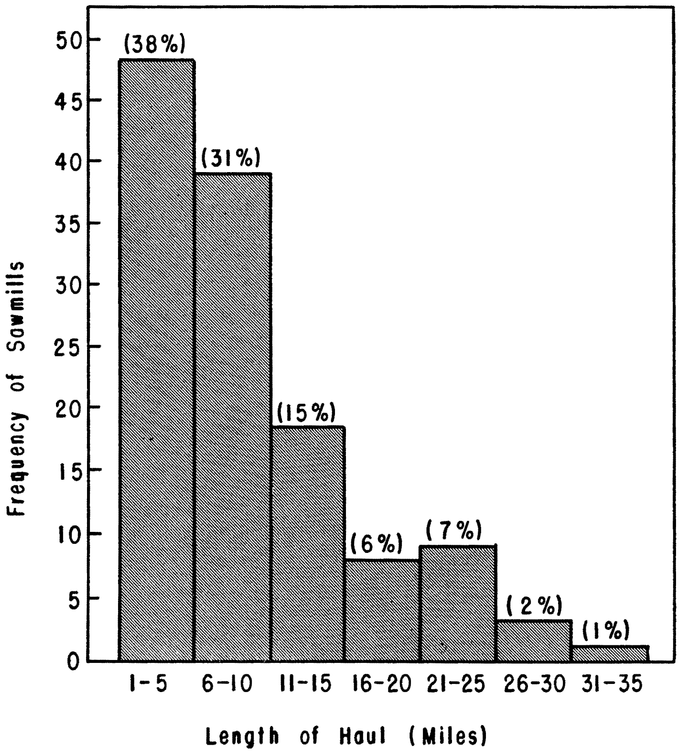

Fig. 6 Distribution of sawmills by average length of haul.

third of these mills were five miles or less on the average from their source of logs. Most mills seemed to be located efficiently with respect to the resources that they use. Many portable mills were situated on tracts of purchased timber and would be moved to new sites when these sources were exhausted. Some large mills, however, hauled over 50 miles to obtain sawlogs of desirable size in sufficient quantities.

The market for forest products can be thought of as starting from the woodlot stump. Log producing and log hauling is a large sector of this market. To locate sawmills most efficiently with respect to their size and portability would require a more detailed study of hauling costs since information is needed. The log hauling sector of the market is complicated further by the fact that many mills transport their own logs and these costs are incorporated in the overall price.

The following section gives a preliminary indication of the pattern of log transportation by counties.

Location of purchase

Table 7 shows that most wood was bought at the stump in this area and almost none bought at the roadside. The percentage bought at the mill was a good indication of the amount of wood hauled by the owners of the woodlots, whereas the percent bought at the stump may have been transported by many means. The sawmills of McCurtain County sawed over half of the total wood in the area. This wood was mainly from non-farm woodlots and may have included some wood from adjoining counties or states. Less than the average of 22 percent was bought at the mill in this county. But in three contiguous counties, Pushmataha, Latimer and Atoka, where mills are in general smaller, more than 50 percent was bought at the mill.

Table 7. Volume Sawn by Purchase Location, 1956

County	County Sawmill Volume	Percent Industry Volume	Percent Bought at Stump	Percent Bought at Mill	Percent Bought at Roadside
	M Bd. Ft.	*percent*	*percent*	*percent*	*percent*
Adair	2,378	3	77	23	--
Atoka	2,861	4	47	53	--
Cherokee	1,055	1	78	22	--
Choctaw	4,947	6	67	27	6
Coal	350	--	100	--	--
Delaware	2,147	3	92	8	--
Haskell	560	1	94	6	--
Latimer	2,025	3	--	100	--
LeFlore	5,810	7	91	9	--
McCurtain	43,181	55	89	11	--
McIntosh	1,263	2	100	--	--
Muskogee	575	1	100	--	--
Pittsburg	3,395	4	62	38	--
Pushmataha	7,970	10	41	58	1
Sequoyah	348	--	69	31	--
TOTAL	78,865	100	78	22	--

Price Variation

Fifteen percent of the sawmills reported price variation for the wood they bought in 1956. Variation at the stump was, naturally, greater than at the mill, due to differences in length of haul and accessability of stand; and the survey showed that, within individual mills, variation at the stump was about twice that at the mill.

Seasonal variation in price paid at the mill was reported by 10 percent sawmills.

Equipment

Major variations in sawmill equipment were in types and numbers of saws, kinds and numbers of power sources, and horsepower of the power sources.

Combination of saws—Table 8 shows the distribution of saw combinations. Forty-five percent of the mills for which complete information was available reported only one head saw. Only three mills were found having a gang saw. Ninety-three percent of the sawmills fell into the class of one head saw plus some combination of edger and trimmer. Gang saws represent a fairly recent innovation for Eastern Oklahoma sawmills. Some mills reported having doubled their output using a gang saw, with very little increase in the other factors of production.

Type of power source—Table 9 presents the distribution of types and numbers of motors used by 128 sawmills in Eastern Oklahoma. Eighty percent of the mills used one or more gasoline motors. These were of a wide variety, from motors still mounted in old automobiles to large stationary engines. Naturally, the duration of service varies. Some motors are replaced every year. The large, stationary types are expected

Table 8. Distribution of Sawmills by Types of Equipment

Frequency of Mills		Type of Saw				
Number	Percent	Head	Edger	Trimmer	Gang	Band
54	45	1	--	--	--	--
18	15	1	--	1	--	--
15	13	1	1	--	--	--
24	20	1	1	1	--	--
1	--	1	2	--	--	--
1	--	1	1	2	--	--
1	--	2	1	--	--	--
1	--	2	2	1	--	--
2	2	1	1	1	1	--
1	--	2	2	2	1	--
1	--	3	--	--	1	2
119	100	124	49	49	4	2
Totals for 130 mills		137	53	51	4	2

Table 9. Sawmills Classified by Number of Motors

Number of Motors	Frequency of Firms Using:				
	Gasoline	Steam	Diesel	Electric	Total Mills
1	90	2	13	1	106
2	23	-	3	1	27
3	1	-	--	3	4
10-15	--	-	--	2	2
20-25	--	-	--	2	2
over 25	--	-	--	1	1
Total Mills Reporting	114	2	16	10	142
Total Motors Reported	139	2	19	586	746

to be in operation for several years, depending on the hours used per year. Mills that have more than one motor use the smaller auxiliary ones to power such extra equipment as trimmers.

The diesel motors were all stationary and were usually of higher horsepower rating than most of the gasoline or electric motors. The initial cost of diesels is usually greater than for gasoline motors, due mainly to the greater horsepower.

Only ten sawmills employed electric motors in their sawmill operation. Only five used electric motors as their primary source of power, smaller electric motors being used to power auxiliary equipment in most cases. The location of some sawmills, especially of portable mills, prevented the use of electric motors.

Horsepower of motors—Figure 7 illustrates the distribution of 128 reporting sawmills by horsepower class. Almost half of the mills used a total of one hundred horsepower or less. The horsepower rating is not too good an indicator of the actual power available. Converted car motors, for instance, had high horsepower ratings but did not deliver their rated horsepower in sawmill operation. Small mills often did not have a power source suitable for sawing large timber for long periods of time.

Most mills operating in the pine counties, and in general nearly all mills operating close to year-around, are adequately powered; and for these mills there is a close association between the total output and the amount of horsepower.

The large variation in the size, type and amount of the different sorts of operating equipment for sawmills in Eastern Oklahoma illustrates a need for further study. This could probably be accomplished best on a case-by-case basis, to determine the optimum type of equipment for various output levels.

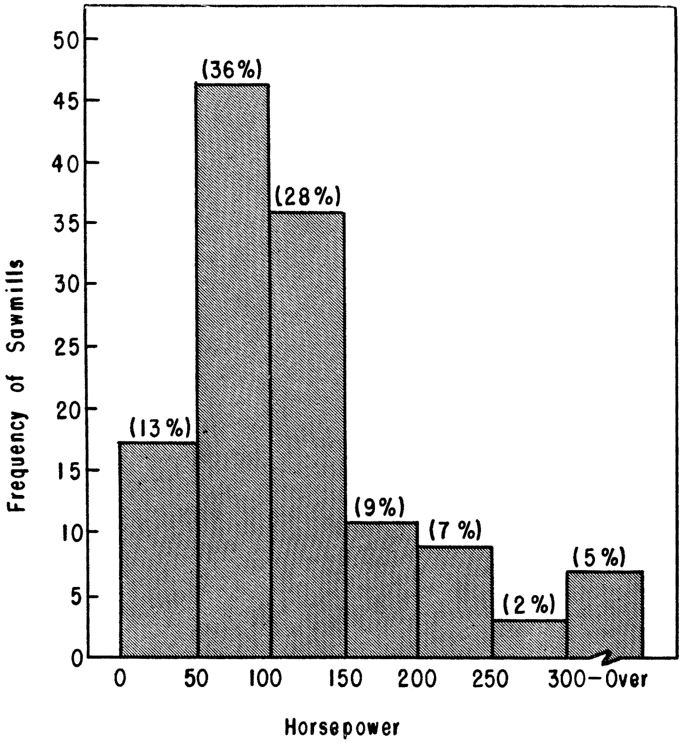

Fig. 7 Distribution of sawmills by horsepower of motors.

Pulp, Prop, Pole, Post and Tie Buyers

Piecewood buyers make up the second largest group in the industry in number of firms. With some exceptions—mainly the tie buyers who buy sawn ties from sawmills or contract to have logs sawn for ties—this group buys wood directly from the forest woodlot with no processing performed on the logs except a certain amount of prop, post and pole treating, usually by contract.

Duration of establishment

A large number of firms were established only recently, as Figure 8 illustrates; but the volume of the business was concentrated in establishments which had been operating for ten years or more. The two largest firms had been operating more than twenty-five years. Increased volume in the industry during the past few years has brought new firms into the industry. Many of these new firms, and some long-

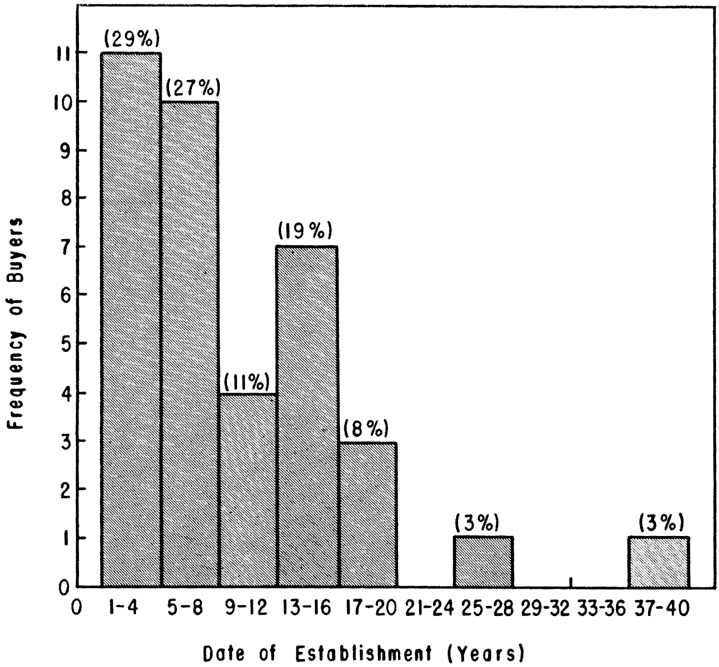

Fig. 8 Distribution of pulp, prop, pole, post and tie buyers by duration of establishment from 1957.

established firms in the northern counties, handle only a few posts as a side-line to their main enterprise: generally, a country store or a hardware store, or perhaps a building materials dealer. Some of the newer buyers were distributing lower grades of wood for processing into structural paper and wallboard.

Size of the work force

Figure 9 shows the distribution of buyers by size of work force. Almost 60 percent have only one person handling the products of the yard. The nine or ten large-volume buyers usually employed three or more workers, and the largest firm, operating in six different locations, employed 100 workers or more. Seventy-seven percent of the firms with only one worker were exclusively post buyers. Seventy percent of these are located in the northern counties, and all except two firms handle only hardwood posts.

Many of the workers employed by the larger firms were employed in the forest woodlots and in hauling wood to and from the yards.

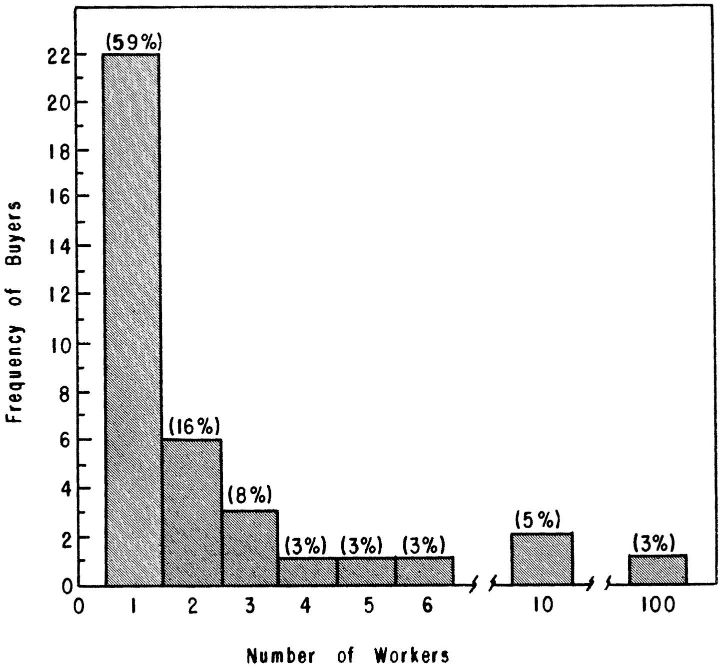

Fig. 9 Distribution of pulp, post, pole, prop and tie buyers by number of usual workers.

Type of product

Of the 37 buyers, 23 bought post and props and 12 bought pulpwood. The post buyers were mainly located in the northern counties, and the pulpwood buyers, naturally, in the pine counties. Only four of the firms bought ties, and three bought poles. Two of the four firms buying ties listed ties as their most important product. Eight buyers handled two or more products, and five buyers handled three or more products.

There appears to be almost no price variation within any given year in this industry and certainly little variation between firms within a single county for a standardized product. This variation is hard to assess due to the lack of standardization of the product and to the differing sizes and qualities of wood handled.

There was almost no variation between counties; the major component of this variation was the different species and qualities of wood located in these counties.

In the pulpwood market, difference in prices seemed mainly due to the location of the outlet with respect to the woodlot from which the pulp was cut.

Length of haul

In general, these buyers hauled wood much further than did the sawmill operators, as Figure 10 illustrates. Seven of the 36 buyers who reported the average length of haul stated that they hauled wood, on the average, 21 miles or more. One firm averaged around 75 miles. Hauling for these buyers in northern counties, which are predominantly hardwood counties, is done mostly by the farmers who cut wood. Hauling in the pine counties in most instances was done by the buyer or by a contract hauler. Especially in the pine area, timber for pulpwood was huled to railroad stations and shipped out of the state for processing without ever reaching the buyer's yard.

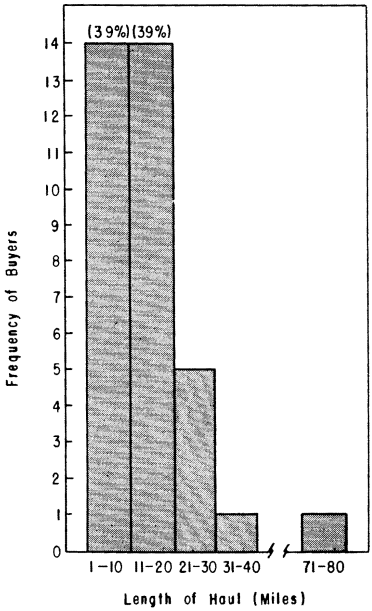

Fig. 10 Distribution of pulp, pole, post and tie buyers by average length of haul.

Miscellaneous Wood Processors

The major types of wood processors other than the sawmill operators and the piecewood distributors are the charcoal markets, the handle makers, and the creosoting plants.

Charcoal makers

There were four charcoal wood buyers in Eastern Oklahoma, located where there was an adequate supply of hardwood. Hickory and oak were the most common types of wood used. One firm had been in operation for forty-one years. The other three had been established since 1956, due to the increased demand for charcoal. A large amount of this charcoal is processed into briquettes. The usual number of workers employed ranged from four to twelve men. One firm operated on a seasonal basis, but others indicated they intend to work on a full-year basis. The newer firms indicated their intention to build additional kilns.

A recent study demonstrated that a much larger charcoal industry could be supported by those Oklahoma forest resources which have no higher use value.[9] The present study found all of the wood used had been obtained from farm woodlots except in one instance where the wood was being cleared for a "dude" ranch. The wood was usually hauled to the charcoal plant by the sellers, but one charcoal maker

Expt. Sta., August 1957, p. 18.
[9] A. C. Pakula, "The Domestic Charcoal Market in Oklahoma," Bul. B-495, Oklahoma Agr.

handled the entire operation from stump to finished product. The haul from the woodlot ranges from 1 to 40 miles, but most of the wood is hauled from 10 to 20 miles. Transportation costs are a limiting factor in the location of the charcoal plant.

Handle Makers

Four handle makers were using wood, mostly hickory and ash, from farm woodlots. Three firms had been established since 1940; the other began operation in 1920. These firms were located in the three-county area of Adair, Cherokee, and Delaware. All firms worked 200 or more days during 1956. The number of men working ranged from one to ten per firm. These mills are somewhat seasonal in their operations, the summer months being a period of slack demand. A large number of axe, mattock, hoe, pick, hammer and maul handles are sold, mostly in the southern and southwestern states. Except for one firm, the wood was cut and hauled to the mill by farmers in the area. Price paid by the mills varied from $18 to $23 per cord. This difference in price was attributable to differences in type and quality of wood and in the end use of the products of these mills. Wood for the handle makers was hauled between 10 and 20 miles, with some large truckloads being hauled up 60 miles.

Creosoting plants

Creosoting plants have been in operation in Eastern Oklahoma since 1907. The five firms reporting on this survey used the pressure treating method. Only one firm of the five operated less than 200 days during 1956, due only to its conversion to the pressure-treating system. Most firms seemed operating at or near capacity during 1956.

The average daily number of men used by the plants is almost 75. Variations in the number of workers employed during the year were slight. At times, adverse weather conditions tended to restrain full operation. Almost 3.7 million cubic feet of wood was processed during 1956. Prices ranged from 35 to 42 cents per cubic foot. Different species and sizes of posts and poles account for most of the difference in price. One firm creosotes only hardwood ties, but the others treat pine posts and poles almost exclusively. Three of the five firms buy their wood from farm-owned woodlots which contribute 45 percent of the wood by volume. Most wood was hauled by contract haulers, with only one firm reporting that half its supply was hauled by farmers. The average haul varied from 10 to 75 miles, with the longest hauls occuring for those firms located outside the pine region.

The creosoting industry in Eastern Oklahoma is one of the most important sectors of the forest economy. It treats over 34 percent of the total value of wood bought by the whole industry, and in 1956 gave employment to at least 120 persons and sometimes as high as 211 persons, for an average of 163 persons for the year. With only one firm processing less than 100,000 cubic feet per year, and one firm processing nearly 1,500,000 cubic feet, and with the most recently established firm processing in its first year of operation nearly 900,000 cubic feet, there are obvious indications that this is a large and growing industry.

Secondary wood users

Planing mills—Of the twelve planing mills enumerated, only two were established since 1956. The oldest was nearly fifty years old. Most of these mills worked a full year in 1956; only three worked less than 50 days. There was considerable variation between the ten mills in the number of workers usually employed, with a range of one to 150 workers. This variation is partly explained by the range of output (30 to 11,000 M.B.F.) and the range of products (1 to 6 products). Most planing mills produce construction lumber; nine produce nothing else. Three mills plane 100 M.B.F. or less, and three plane more than 1,000 M.B.F. One half of the wood planed was hardwood, and most of this was planed by one mill. Only eight counties have a planing mill, and the pine counties contained nine of the twelve mills.

Mills had an average haul ranging from 10 to 75 miles, but half of them hauled 25 miles or less. One mill hauled up to 90 miles occasionally. Hauling was done usually by truckers or sawmill operators.

Planing mills favored small stationary gasoline or butane motors as their main power source, but two units used a diesel motor and many used several small electric motors in addition to the main power source. Total horsepower used ranged from 22 to 1,460 H.P. per mill, with half of the mills employing 100 to 200 H.P. each.

Furniture makers — This category of secondary processors provided employment for seventy nearly year-round jobs. Two of the six firms were established since 1956. These firms turn out furniture, handle blanks, truck beds, and gun stocks, and process nearly two million board feet of lumber. They paid from $30 to $95 per M.B.F. for their wood purchases. Most of them use special varieties of wood such as hickory, pecan, and ash. Half of these firms bought all their wood from farmers who hauled most of it to the makers' yards. Some of the other firms traveled as far as 100 miles for some of the rarer species and qualities of wood.

OUTPUT AND COSTS IN THE SAWMILL INDUSTRY

An attempt was made to assess the output efficiency of the sawmill segment of the forest processing industry in Eastern Oklahoma. Sawmills were selected for analysis for several reasons. First, they are one of the most important segments of the industry. Secondly, there are enough of them to provide adequate data for statistical determination of output efficiency. Thirdly, lack of sawmill capacity would constitute a major restriction on any possible increase in the use of forest resources in Eastern Oklahoma. And, last, there are enough basic differences in methods of operation to permit comparison among different types of firms.

Classificaton of Firm Type

Data from 114 sawmills were complete with respect to output and the most important factors determining cost. These firms were classified with respect to their saw equipment. They will be referred to as Types I to V:

Type I, sawmills with one head saw only (54 mills);
Type II, sawmills with one head saw and one trimmer (18);
Type III, sawmills with one head saw and one edger (15);
Type IV, sawmills with one head saw, one trimmer, and one edger (21);
Type V, Others (6). Three of these had one gang saw, and the other three had more than one saw of a particular type.

Within these types, much variability in equipment remains. The major variability is in the type and size of the power sources; therefore, the cost of such power sources was used as a variable cost within each type.

Data Used

The data used in this section is standardized for each firm at an estimated 200 days of operation. The last section of the study will illustrate how important the length of yearly operation is to considerations of capacity. Two hundred days was chosen as the minimum time of operation that could be expected if sufficient wood supplies were available and as weather permitted.

Output

The output of each firm was divided by the number of days the firm operated and then multiplied by 200. Output is quoted in thousands of board feet log scale (M.B.F.).

Costs

A distinction is made between total costs and unit costs. By total costs is meant the total cash outlay for a year's operation; by unit costs is meant the total costs incurred during a year's operation to produce one unit of wood in the 200 days. In other words, total cost divided by output in 200 days is unit cost. This last figure is quoted in dollars per M.B.F.

Fixed costs

The yearly costs associated with fixed equipment were estimated by applying prices and depreciation rates to the different types of equipment used by each type of firm. Approximately average prices for this equipment and their rates of depreciation were furnished by Mr. C. L. Clymer, forestry specialist in the Oklahoma Extension Service. These prices were checked by small telephone samples to representative firms of the different types.

Table 10 shows the composition of these estimated yearly fixed costs by type of firm. They represent, for each type of firm, an average weighted by the proportion of the firms within the group using different sizes of equipment. The actual replacement values of each size and type of equipment are known, and the average length of life is known. But, since there is variation within any firm type, few individual firms are using the equipment represented by the weighted average. Perhaps the widest actual variation in equipment among individual firms occurs in the category labeled "Other" in the table.

Variable costs

The variable costs were assumed to consist of only three types: motor, fuel, and labor.

For motors, price information on the various kinds of motors was obtained from a sample of manufacturers and checked with the Agricultural Engineering Department of Oklahoma State University. For any motor of given kind (gasoline, diesel, butane, electric) and horsepower, one price, the lowest quoted for adequate sawmill power characteristics, was used. The yearly cost was taken as the following percentages of the new price; 15 percent for gasoline and low pressure fuel motors; 12 percent for diesel and kerosene motors; and at 8 percent for electric motors.

For fuel operating costs, a year of 1,600 hours was used as average fuel consumption specified by the makers and at local prices for the different fuels.

For labor costs, a year of 1,600 hours was also used. Each headsaw and gangsaw was assumed to have a sawyer at higher rates than the remainder of the work force. For Types I-III, the rate used was $1.50 for the sawyer and $0.75 per hour for the other workers. For Types IV and V, the rates used were $1.75 and $1.00, respectively. Table 12 shows the distribution of variable factors and their imputed costs averages by type of firm.[10]

Relation of Output and Unit Costs

Theoretical considerations

The economist looks upon output and unit cost not as two separate variables but as a related system. Output levels are attained at the expense of inputs. But there is an important distinction between the fixed and variable inputs of which account must be taken. The more logs sawn, the more fuel and men are needed for any given size of plant; but plant size imposes an upper limit on the amount of sawing that is physically possible.[11]

[10] Management skills were assumed equal between firms and free of cost.

[11] It is assumed throughout that there are no monetary economies or diseconomies associated with changes in the use of variable inputs. In other word, these inputs may be purchased at the same price regardless of how many are used.

Table 10. Averaged Costs Associated with Fixed Sawmill Equipment[1] (dollars)

Class of Firm		WEIGHTED AVERAGE REPLACEMENT VALUE OF FIXED EQUIPMENT[2]							Yearly Fixed Costs[5]
Type	No.	Headsaw[3]	Carriage[4]	Trimmer[4]	Edger[4]	Gangsaw[3]	Bandsaw[4]	Other[1]	
I	54	178	297	---	---	----	----	500	124
II	18	178	297	70	---	----	----	500	131
III	15	178	297	----	180	----	----	500	142
IV	21	207	473	96	189	----	----	1,000	228
V[6]									
1	1	325	2,175	400*	225	----	----	10,000	1,339
2	1	650*	4,350	200	450*	----	----	10,000	1,663
3	2	325	14,934[7]	200	225	2,241	----	20,000	4,177
4	1	650*	17,109	400*	450*	2,241	----	20,000	4,519
5	1	975**	19,284	----	---	2,241	850*	120,000	14,818

*Two pieces of relevant equipment.

**Three pieces of equipment.

1 Does not include cost of motor which varies widely within each firm type.

2 The value for each firm type is an average weighted by the proportion of firms using each size.

3 Twenty-five percent of the replacement value is attributed to each year.

4 Ten percent of the value yearly.

5 Sum of the depreciated values.

6 Type V is a gross aggregate of six very different large firms. This table does not disclose actual data for the individual firms of this type, only an approximation with respect to the number of pieces of equipment averaged over all firms using the equipment.

7 Includes gangsaw assembly where gangsaw used.

Table 11. Averaged Costs Associated with Variable Sawmill Inputs[a]

Class of Firm		FIRM MOTOR EQUIPMENT								200-Day Motor Operating Costs[6] (Firm Avg.)	200-DAY LABOR			Average of all Variable 200-Day Costs[9]
		Numbers[2]			Average Power				Avg. Yearly Cost[5]					
Type	No.	Gas[3]	Dsl.	Elec.	Gas H.P.	Dsl. H.P.	Elec. H.P.	All[4] H.P.			Avg. No.[7]	Modal No.	Avg. Costs[8]	
I	54	55	4	0	78	67	--	85	276	1,591	2.4	2.0	4,067	5.934
II	18	22	1	0	67	100	--	88	298	1,654	2.5	2.0	4,200	6,152
III	15	15	4	0	87	103	--	114	393	2,118	3.6	3.0	5,520	7,031
IV	21	25	3	4	99	102	41	140	461	2,832	5.0	3.5	9,124	12,417
V[10] 1	1	1	2	25	N.A.	N.A.	N.A.	500	1,514	11,279	12.0	1	21,600	34,393
2	1	1	2	3	N.A.	N.A.	N.A.	600	914	5,678	8.0	--	15,200	21,792
3	2	2	1	29	N.A.	N.A.	N.A.	530	989	6,479	9.5	--	19,200	26,668
4	1	3	0	20	N.A.	----	N.A.	1,200	997	7,296	15.0	--	27,600	35,993
5	1	0	0	500	--	--	4	2,000	14,246	54,400	25.0	--	56,000	116,253

[1] Simple averages over the firms in one type including the averages of unit costs.

[2] Many firms have more than one motor and some have more than one type of motor.

[3] Includes kerosene, gasoline and low pressure fuels. Firms operating with steam excluded.

[4] Average total power per firm.

[5] Estimated weighted average from sample of price lists for similar equipment, taking 15 percent for gas, 12 percent for diesel and 8 percent for electric of the new value for each type as the yearly cost.

[6] Applying average fuel costs to each firm by type of equipment for eight-hour day.

[7] Employed in sawmill operations only.

[8] Averaged by firm type allowing for differences in wages paid to sawyers versus helpers weighted by the actual distribution of these rates between firm types.

[9] Sum of the three types of unit costs which are variable within firm types.

[10] Data quoted for individual firms do not disclose actual costs but are estimated similarly to other firms..

When all inputs are doubled, it would be expected that output would double, and, since cost also doubled, that unit cost would remain the same. But with plant held fixed, an increase of variable inputs (in the proper proportions to gain maximum output for their joint cost) may decrease cost per unit of output. This happens because, although the cost of the variable input has increased, the cost of the fixed plant has remained the same and has been "spread" over more output.

The decrease in unit cost may be rapid at first, but will slow up as more and more variable inputs, such as men and motor power, are applied to the fixed plants. In fact, it may slow up to the point where, above a certain output with fixed equipment just not able to cope with the large inputs of men and motors, unit costs actually increase. So the relation between unit costs and output is viewed as one, where, as output increases, unit costs decreases but at a slackening rate of decrease so that there is some floor to unit costs for any given plant size.[12]

For a larger plant, with higher fixed costs, the same argument applies but over higher ranges of output. A plant of Type IV, having yearly fixed costs of $228, would be expected to produce *both* a higher range of output *with* a lower range of costs than a sawmill of Type I with $124 of fixed cost. Table 12 shows that, with increasing "scale" through the various types of firms, this effect is present in the sawmill industry of Eastern Oklahoma with only one exception.

There are naturally dangers involved attempting to represent, and especially to estimate, the relationship between output and unit costs by observing groups of firms with similar equipment. There are other unobserved inputs as well as those which are perhaps incorrectly observed. A cost relationship theoretically assumes that each operator-manager has equal skill in combining inputs, that the variable inputs are put together in minimum cost combinations for a given output, and that the process of production used is the best available with the set of all inputs. These three assumptions are seldom met in practice. The second assumption of minimum cost combinations is perhaps the least realistic. There are many sawmills with one small headsaw using a huge but inefficient motor and one man to operate the plant. Some similar plants have a small automobile motor still mounted in the chassis and up to a half dozen underemployed men operating the mill. Nevertheless, with all these qualifications in mind, some general judgments may be arrived at about relative efficiencies of the different sawmill types.

Empirical differences between firm types

Table 13 shows that as we pass from one type of firm to the next, the range and the average of output increase and the range and the

[12] The cost function cannot be described only in terms of its slope. A mathematical definition for the set of cost functions considered would be, where $y =$ unit cost and $x =$ output, for any firm; $O < x, y <$ "Infinity," real; $y = f(x)$, single-valued; and $d^2y/dx^2 \geq O$, continuous.

Table 12. Averages by Firm Types of Output, Costs, and Unit Costs[1]

CLASS OF FIRM		AVERAGE OUTPUT[2]				AVERAGE COSTS			AVERAGE TOTAL UNIT COSTS	
Type	No.	Actual Output[3]	Days Open	200-Day Output	Range of 200-Day Output	Fixed	Variable	Total	Average 200-Day Unit Costs	Range of Unit Costs
		MBF	No.	MBF	dollars/MBF	dollars	dollars	dollars	dollars/MBF	dollars/MBF
I	54	102	83	239	50- 758	124	5,934	6,058	25.30	9.89-185.64
II	18	173	101	271	47- 600	131	6,152	6,283	23.20	10.30-107.45
III	15	191	83	410	53-1846	142	7,031	7,173	17.50	7.37-135.10
IV	21	660	170	753	115-2000	228	12,417	12,645	16.80	5.68- 92.04
V[4] 1	1	5,000	240	4,167	--	1,339	34,393	35,732	8.57	--
2	1	1,500	220	1,364	--	1,663	21,792	23,455	17.19	--
3	2	3,000	235	2,509	1818-3200	4,177	26,688	30,845	12.29	10.27-15.85
4	1	6,000	250	4,800	--	4,519	35,993	40,512	8.44	--
5	1	30,000	250	24,000	--	14,818	116,253	131,071	5.46	--

[1] Averages of costs weighted by 200-day outputs.

[2] Total output of the firms included equals 72,877 M.B.F.

[3] Nineteen firms with insufficient data have been left out. Their total output is nearly 6,000 M.B.F. One firm of Type IV using steam produces 4,000 M.B.F. working year round for a roughly estimated unit cost of $15.28 including imputed fuel costs. The fuel used, however, is waste wood.

[4] Only the figures in output reveal actual data for individual firms.

Table 13. Parameters of the Distributions for Five Major Types of Sawmills of Their 200-Day Output and Unit Costs as Observed Over 114 Eastern Oklahoma Sawmills in 1956

FIRM		OUTPUT[1]				UNIT COST[2]					RELATIONSHIP[3]		
											Per Cent Unit Cost Variability Explained by Output Variation[10]		
Type[4]	No.	$\bar{X}$[5]	Median[6]	R.Q.D.[7]	Per Cent Below $\bar{X}$[8]	$\bar{Y}$[5]	Median[6]	R.Q.D.[7]	Per Cent Above $\bar{Y}$[8]	Output Weighted Mean[9]	Poly[11]	Log[12]	Freehand[13]
		M.B.F.	M.B.F.	Percent			Dollars/ M.B.F.	Dollars/ M.B.F.		Dollars/ M.B.F.			
I	54	239	200	52.0	57.4	33.58	25.74	39.5	74.1	25.30	54.0	83.3	73.5
II	18	271	200	69.0	61.1	34.88	28.87	49.3	66.7	23.20	81.3	84.4	94.4
III	15	410	300	33.3	80.0	37.42	23.23	50.07	66.7	17.50	62.9	90.2	96.2
IV	21	753	600	62.3	52.4	22.21	15.99	33.9	66.7	16.80	54.4	77.7	77.5
V	6	7,368	3,684	40.5	83.3	10.36	8.77	29.8	66.7	7.22	---	---	99.0

[1] Output adjusted to 200 days for each firm.

[2] Fixed and variable yearly cost in dollars divided by 200 day output for each firm.

[3] As explained in the text, unit cost and output are theoretically a joint distribution.

[4] Types defined in text. The "parameters" for Type V represent a gross aggregate of six, very different, large and efficient firms.

[5] The arithmetic mean of the distribution, Bar $X = (\sum_i X_i) \div N$.

[6] The middle firm of the type; $Q_2 = (N \div 2)$th firm, the second quartile.

[7] Measure of relative dispersion, $R.Q.D. = 100(Q_3 - Q_1) \div 2Q_2$.

[8] Number of firms below or above the mean of the firms as a percentage of all firms in the type.

[9] Average of firm unit costs weighted by output for each firm. This weighted mean lies closer to the function than the unweighted mean since the functional relationship is non-linear.

[10] The coefficient of correlation defined as $100R^2 = 100 (\sum y^2 - S.S.E.) \div \sum y^2$, where $\sum y^2$ is the mean moment of unit cost and S.S.E. are the sums of squares of deviation from the fitted curve.

[11] The fitted function was a second degree polynomial in output.

[12] Linear in logarithms of unit cost, and natural units of output.

[13] Smooth curve, decreasing at a non-increasing rate, drawn freehand attempting to leave as little squared deviation from observed points as possible. Statistically suitable functions are not always delicate enough to follow the observed coordinates closely.

average of unit cost decrease. Only one firm (of Type V) is exceptional having a larger output from a smaller fixed cost plant than the succeeding firms. Thus the data do not reject the theoretical propositions stated above.

These results, however, are less than fully satisfactory for evaluating relative efficiencies. Figure 11 shows the empirical relationship between unit costs and output for the various sawmill types. The freehand curves were fitted as closely as possible to the single-firm observations for each firm type. Only the part of the curve below the average of unit costs for each firm type is drawn, since nearly 70 percent of all observations lie below this average.

It will be seen that, in addition to the differences between types of sawmills, there are considerable differences within each type. Type I goes to a minimum of $9.00 per M.B.F. at around 550 M.B.F. yearly output. Increases in output beyond this point seem to be achieved at the expense of increased unit costs. But up to around 725 M.B.F. per 200-day year, it is still the most efficient type of firm. Then Type III takes over, but it does not achieve unit costs of $9.00 per M.B.F. until some 1,250 M.B.F. of output.

Type II has higher unit costs than Type I for all output. So, the addition of a trimmer hampers economic production efficiency. But it may not hamper marketing efficiency since, at equal prices, there is perhaps more demand for square-end than for untrimmed boards.

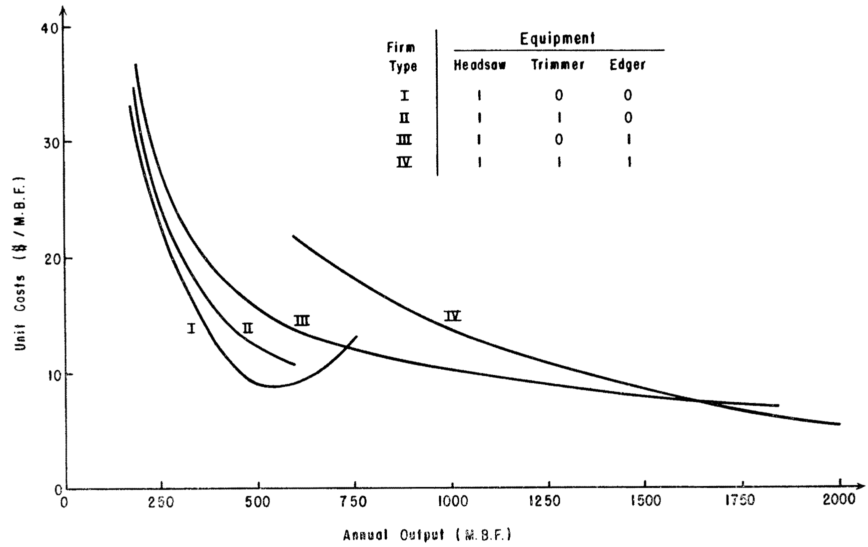

Fig. 11 The observed relation between unit costs and output in eastern Oklahoma sawmills within four farm types, 1956.

Many planing mills and most retail consumers insist that rough-cut lumber be trimmed. Over a range of output between 200 and 600 M.B.F., the addition of a trimmer added between one and three dollars of costs per M.B.F.; in fact, up to a 30 percent increase at around 500 M.B.F. of output. It is questionable whether sawmills actually obtain a three dollar price premium per M.B.F. for trimmed lumber, but certainly there is a wider market for it at any price.

It appeared that Type IV firms gain in efficiency over Type III only for high outputs of 1,700 M.B.F. or more. But, again, the addition of the trimmer may well gain more saleability for the product.

The most interesting and valid difference between the firm types is the larger increase in efficiency, in terms of lower unit costs, gained by the addition of the edger. A headsaw can be, and is, of course, used to edge sawn lumber in mills that do not possess an edger. But this wood has to be stacked twice in the usual operation and the resulting loss of efficiency is quite large. From the relationship in Figure XI, it can be seen that, with or without the trimmer, the sawmills with an edger have a considerable "edge" over those without. Of those sawmills with no edger, not one sawed more than 750 M.B.F. (log scale) in 200 normal operating days. In fact, half of them sawed 200 M.B.F. or less. But the sawmills with an edger sawed a much greater amount; half of the mills of Type IV sawed 600 M.B.F. or more. Only 15 percent of the mills with no edger, but 33 percent of those with an edger, had unit costs of $15 per M.B.F. or less. Some 43 percent of the firms of Type IV sawed logs at a cost per M.B.F. of less than $15.

In general, it may be concluded from these observations that the types of mill differed mainly in output potential. There was little difference in the efficiency of the different types of firms, providing the right output was chosen for each type. But the larger types became more efficient at large outputs; in fact, more of the firms with large fixed equipment produced high outputs, and did it with smaller costs. But the larger the equipment, the more vital the need to use it sufficiently to obtain its full potential for reducing unit costs.

Empirical differences within firm types

To the individual operator, and the industry, the joint distribution of unit costs and output within a given type of firm is perhaps more important than differences between types. Knowing best to use a given set of fixed equipment is more immediate than choosing the optimum set of equipment.

Table 13 illustrates the high degree of variability of unit costs and outputs within each type of firm. It also compares this variability between firms and the proportion of the unit cost variability than can theoretically be imputed to variation in output.

Types I, II and III are evidently low output firms, although three firms of Type III produce more than 500 M.B.F. per 200-day year. The median demonstrates this typical difference best since it points out the central firm in output terms for each type. For Type IV, half the firms produce 600 M.B.F. or more. Type V firms are, of course, distinguished for their high outputs. The relative quartile deviation illustrates how dispersed the outputs are for firms of a given type. It is a reasonable approximation that 50 percent of the observations differ from the median not more than the quartile deviation.[13] So, half of the firms of Type III differ by only 100 M. B. F. from the median of 300 M.B.F. whereas half of those of Type IV differ by 375 M.B.F. from a median of 600 M.B.F. which in a relative sense means that the outputs of firms of the third type are half as diverse as those of the fourth. This is shown by relative quartile deviation of 33.3 and 62.3 percent of the median, respectively. In addition to being the least dispersed in output, Type III is the most skewed. Four fifths of all the firms of Type III have outputs below the average. The one very large firm in Type IV makes this output distribution badly skewed.

In summary, with respect to output, the firms of each type are quite dispersed, and badly skewed to the left. This means there is not only great range in output, but it is not concentrated at any point and, it is usually lower than the over-all average. Type III is the most concentrated firm type, but Type IV is the least skewed.

The distributions of unit costs within each type of firm indicate similar conclusions. But variation in output explains a large proportion of the cost variability in each type. The worst percentage explanation of unit cost variability by output is about 78 percent for Type IV, so that for all types of firms the relationship is fairly close. Thus, the distributions of cost and output can be compared jointly. For all types of firms, at least two-thirds of the members have costs above the average and these costs are closely associated with outputs that are below the average.

The potential efficiency of all types of firms, even when standardized at 200 days' operation, is not being exploited—except by a fraction of firms. This is true for all types.[14] Each type is capable of considerable efficiency as shown by the previous section, but few firms exploit this capability. This is especially true for the smaller firms. Only in the group of firms with the full set of headsaw, trimmer, and edger, did a large proportion of individual firms come close to operating near maximum efficiency. Much more saw timber could be processed at smaller unit cost (provided log supply and lumber demand were adequate).

Difficulties of location can explain only part of the wide variation in efficiency within the various types of mills. This study made little

[13] More correctly, $P(|K-X| < Q.D.) = 0.5$ where $K = (Q_3+Q_1) \div 2Q_2$ for a symmetrical distribution.

[14] Type V, an aggregate of many kinds of firms, must be excluded from these statements.

attempt to evaluate these difficulties beyond observing that there is a close association between available supplies of logs and both number of mills and their efficiency. The five pine counties, for instance, have the major share of the mills and these mills operate mostly in the higher range of output and lower range of unit costs.

THE ECONOMIC CAPACITY OF THE SAWMILL INDUSTRY

Faced with larger future demands for wood products and the possibility of expanding the supply of sawlogs from the local forest resources, the sawmill industry will need to expand its processing if local resource owners and workers are to reap the benefits from such expansion.

Potential Demand and Supply Conditions

Future use of wood products

It has been estimated that, by 1975, the demand for industrial wood in the United States will have increased by 25 to 40 percent over the 1952 use.[15] Meanwhile, the demand for fuel wood will have dropped by 25 percent. The Forest Service further calculated an upper level estimate of demand for live sawtimber by 1975 of 44 percent above 1952. This estimate was made on the basis of upper level projections of population, of gross national product, and of the relation between these two factors and sawtimber demand. For Eastern Oklahoma, assuming a constant share of the nation's production, this would imply an increase from about 80,000 M.B.F. to 115,000 M.B.F. When taking into account the different composition by species, Oklahoma's increase would be somewhat less than the national average, (105,000 M.B.F.). This is due to the smaller proportion of softwood in Oklahoma. In recent experience, the high figure is usually the safer projection, so the demand potential assumed will be 115 million board feet for the fifteen counties of Eastern Oklahoma. The presently unknown, future relationship between price and costs will be assumed constant. Oklahoma income levels have been rising faster than those of the nation. Per capita personal income rose 231 percent from a 1929 level of $454 to the 1955 average of $1,506. The United States as a whole rose 163 percent to $1,847 by 1955. Since the disparity is increasing, Oklahoma will have to grow even faster to catch up. But, with the advantage of close location, the Eastern Oklahoma sawmill industry might possibly expect to obtain a greater share of the total expected demand for forest products than the average for the nation. This will depend also on the net growth potential of the local forests, the ability of the industry to produce and process the wood, and the competitive position of substitutes for Oklahoma wood products.

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[15] Edward C. Crafts, "Timber Resources for America's Future," **Timber Resource Review,** Forest Service, U.S.D.A., Washington, D. C., September 1955, p. 28.

Potential production from the forests

Of the 245 million board feet of saw-timber net growth in 1955, only 115,000 M.B.F., or 48 percent, was actually cut. Assuming the same relationships for saw-logs as for the total saw timber, this implies that the output of saw-logs in Eastern Oklahoma could have been 116,000 M.B.F., which is roughly equivalent to the projected 1975 demand.

Local forest workers estimate that in twenty years the yearly net growth could increase by 50 to 100 percent. Through the application of minimum to moderate improvements in forest management. Oklahoma net growth could increase to 367 or 490 million board feet from existing acreages. At present rates of cutting, this would mean between 172 and 225 million board feet of saw timber cut with perhaps 118 to 154,000 M.B.F. needing to be processed by sawmills in the 15 counties of this study. About 150 million board feet will be taken as the possible processing the sawmills will need to face by 1975 under conditions of maximum local output of saw-timber.

To increase the production of the local forests to 150 million board feet will require considerable improvement over present practices. This improvement would be needed mostly in the small farm woodlots since the large tracts of commercial land operated under non-farm ownership have, in general, experienced better forest management. But improvement of farm forest tracts of 50 to 100 acres is a more difficult problem, not only due to the scale of operation, but also to the availability of farm resources such as labor and capital (including considerations of their alternative opportunities on the farm and elsewhere).

Sawmill Capacity at 200-Day Operation

Most of the large mills operate full time while some smaller mills operate for only one month. The fact that the small mills operated at all implies there is some economic advantages from using their equipment so that, to assume they can operate full time, given a market for their product, only implies that a work force is available in the locality and that their equipment would sustain year-round use. The first implication is not troublesome in Eastern Oklahoma with considerable underemployment. The second is not valid in some cases where the sawmill plant is largely worn out.

With these reservations, if all mills operating less than 200 days were brought up to at least 200 days' operation, with their daily output and input rate the same and with their existing equipment, the total production in the local sawmill industry could increase by nearly 23 percent. The current aggregate production of firms with adequate data is 78,342 M.B.F. With these mills all operating at least 200 days, the output in terms of logs sawn would increase to 96,217 M.B.F. or roughly 84 percent of the demand projection and 64 percent of the production potential. Such a change would not affect unit costs as herein defined. For the present demand and supply situation, the sawmill industry was working at 81 percent of capacity as measured by possible output at full-time yearly operation.

Sawmill Capacity with Existing Plant

Method of estimation

Of the large number of possible methods to estimate capacity output and unit costs, it was decided to examine the more efficient firms in each group from Type I through Type IV. From each of these four types were selected firms which fell in the low fifth (quintile) of the distribution of unit total costs. The outputs and costs were calculated on a 200-day basis. The unit costs used were output weighted averages. Apart from the ease of computation, this method allows examination of the actual cases of efficient operation within each type of plant for existing sawmill firms. Other more sophisticated methods were tried, but found wanting.[16]

Since Type V firms are so differently organized and equipped, and all working nearly the full year, their present levels of total outputs and unit costs were held constant. It is reasonable to suppose that the plant of such large firms was built efficiently to take care of the maximum expected demand for their product and that changes in their output will be forthcoming by reorganization more swiftly than for the smaller firms. Two of the largest firms have already so reorganized, and in 1957, increased their output by a considerable percentage over 1956: in one case, by better use of existing plant; in the other, by establishing a new plant. Other firms with insufficient data are held constant in the same manner.

Results

The total output of the 133 sawmills would have been 95,257 M.B.F. under the conditions outlined above.[17] From this base, which is 21 percent above actual output, the capacity of the industry with existing plant will be estimated.

Table 14 illustrates the potential increase in capacity of the sawmill industry if firms in the first four types operated at levels similar to the most efficient fifth in each type. Under the assumptions of the estimation process, it is seen that the existing firms in the industry could handle 135,251 M. B. F. of sawlogs at a considerable reduction in unit cost. This represents an increase of 71 percent over the actual 1956 output, 42 percent over the 1956 base as described above, and

[16] Restrictions of economic theory on the form of the unit costs function are quite loose. Statistical restrictions together with those concerning ease of computation are more hampering. Hyperbolic and logarithmic functions do not reach a minimum at finite outputs. Polynomials are not "delicate" enough and reach a minimum sometimes at negative unit costs. See the Appendix for further details.

[17] This is less than 200-day capacity as estimated since some mills in Type I through IV were working more than 200 days.

18 percent more than the 1975 estimated demand of 115,000 M.B.F. On this basis, the sawmill industry can be said to be working at 58 percent of capacity with respect to full-time yearly operation and optimum plant efficiency for existing firms. But even under these optimum conditions, it will be noted that the industry, as presently constituted, could process only 90 percent of the possible output of 150 million board feet of sawlogs in 1975.

Characteristics of the most efficient firms

To gain some insight into the nature of the firms of each type that operate close to the maximum firm efficiency, their basic characteristics in terms of variable input levels were investigated. Table 15 shows these characteristics.

Gas power is favored with one gasoline (or low pressure gas) motor being by far the most common power source for all firms. The horsepower of this source varies considerably, but in general, is higher than that of the motors for less efficient firms in any type. It is concluded from examination of the individual firms that a gasoline motor of 80 H. P. is adequate for efficient operation of a headsaw and trimmer, but the addition of an edger used simultaneously requires at least another 40 H.P. Such conclusions should be reinforced by actual case studies of an economic-engineering nature.

Table 14. Output and Unit Costs of Most Efficient Firms and Capacity with Existing Plant

FIRM		1956 ACTUAL OBSERVATIONS[1]			MOST EFFICIENT FIRMS			CAPACITY
Type	No.	Average Output	Weighted Average Unit Cost	Adjusted Output	No. Used	Average Ou'put	Weigh'ed Average Unit Cost	Total Output Potenial
		MBF	dollars/MBF	MBF		MBF	dollars/MBF	MBF
I	54	102	25.30	12,929	11	445	13.86	24,030
II	18	173	23.20	4,875	4	506	12.50	9,108
III	15	191	17.50	6,149	3	1,049	9.96	15,735
IV	21	660	16.80	16,804	4	1,518	9.18	31,875
V	6	8,083	7.22	48,500	6	8,083	7.22	48,500
Others	19	316	----	6,000	19	316	----	6,000
Total	133	716	----	95,257	--	1,017	----	135,251

[1] Adjusted to 200-days' operation for firm Types I to IV.

Table 15. Variable Inputs of Most Efficient Firms

FIRM		MOTOR					LABOR				
		Distribution of Motor Type				Ave.	Distribu'ion				Modal
Type	No.	1 Gas	2 Gas	1 Diesel	2 Diesel	Power	1-2	3-4	5-6	7-8	Number
I	11	8	2	1	0	97	8	3	0	0	2
II	4	4	0	0	0	70	2	2	0	0	3
III	3	1	0	1	1	145	1	0	1	1	5
IV	4	4	0	0	0	124	0	1	1	2	6

The work force varies considerably but there is some symmetry in the usual number of men employed by the efficient firm of each type. Of course, those of Types III and IV may be working closer to maximum efficiency than Type II. But the eleven firms of Type I are working close to maximum efficiency for firms with one headsaw. The two firms with the highest output are beginning to experience diseconomies to their variable factors as measured by increasing unit variable cost beyond an output of about 550 M.B.F.

In summary, then, the sawmill industry was working at far less than capacity. Firms in the smaller types were the main contributors to the undercapacity observed. With existing plant and equipment, but with considerably higher levels of variable inputs such as men and motor power, a volume of 135 million board feet could be handled by the industry if the smaller firms worked full time and closer to maximum firm efficiency. An increase in the output of the six large firms in Type V of 30 percent would bring the industry output up to 150 million board feet—the upper level of production predicted for 1975.

One large firm has already experienced such a change, and, as mentioned before, another is equipping its plant for an increase in output and efficiency. The process of change for the first plant is worthy of notice. In 1954, it was operating with a headsaw, a trimmer, and an edger, at close to maximum efficiency. The addition of a gangsaw increased its output, but, for the first year, did not decrease its unit cost very much, if at all. Then, with an increase in the number of men employed and an improvement in organization, output was still more increased and unit cost considerably decreased since the additional total cost was far outweighed by the additional output. Figure 12 illustrates a theoretical view of this process. The cost curves can only be implied from the data on other similar firms.

Capacity with Optimum Equipment

The smaller firms in the industry were working far under capacity

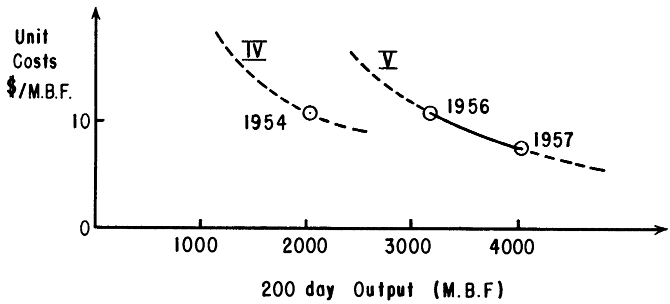

Fig. 12 Progress toward efficiency—an actual case.

with respect to time operated and the efficient operation achieved by the better firms. The larger firms were operating under capacity with respect to potential output although close to minimum unit cost. Therefore, future demands on the sawlog processing industry are likely to be met with respect to every factor but location. Even the large firms will be economically restricted from going too far for their log supply. The estimation of industry capacity will thus have to include some reference to the location of forest resources.

Method of estimation

Taking 150,000 M.B.F. as the 15-county production potential by 1975, the expected county distribution of this total was calculated on the basis of the 1956 distribution by hardwood and pine. This allocation was performed with respect to both saw timber stands and present sawlog output. Table 16 shows the results.

Since the existing saw-log haul averaged only nine miles and the counties are sometimes fifty miles across, the optimum number of mills in each county was adjusted for an upper limit of haul of fifteen miles. Only 16 percent of the mills now haul more than fifteen miles on the average.

Although the economic capacity of an industry means that under pure competition all firms operate with ideal equipment for their

Table 16. Estimated Distribution by Counties of the 1975 Sawlog Production Potential on the Basis of 1956 Live Sawtimber and Sawmill Output

COUNTY	1956 Live Sawtimber[1]			1956 Sawmill Output[2]			1975 Output Potential[3]		
	Pine	Hdwd	Total	Pine	Hdwd	Total	Pine	Hdwd	Total
				—million board feet—					
Adair	12.8	93.5	106.3	.2	2.2	2.4	.5	3.1	3.6
Atoka	7.8	97.4	105.2	1.3	1.6	2.9	1.5	2 5	4.0
Cherokee	16.7	101.8	118 5	--	1.1	1.1	.5	2.1	2.6
Choctaw	--	242 5	242.5	4.1	.8	4.9	3.9	3 4	7.3
Coal	--	75.0	75.0	--	.4	.4	---	1.1	1.1
Delaware	--	60.0	60.0	.1	20.0	2.1	.1	2.5	2.6
Haskell	3.4	146.0	149.4	.2	.4	.6	.3	2.0	2.3
Latimer	42.4	56.3	98.7	2 0	--	2.0	3.0	.6	3.6
Le Flore	298.0	234.4	532.4	5.7	.1	5 8	13.6	2.6	16.2
McCurtain	1147.2	413.6	1560.8	38.3	4.9	43.2	68.1	9 0	77.1
McIntosh	--	15.6	15 6	--	1.3	1.3	---	1.3	1.3
Muskogee	--	86.7	86.7	--	.6	.6	---	1.5	1.5
Pittsburg	3.2	41.6	44.8	.7	2.7	3.4	.7	2.9	3.6
Pushmataha	452.8	155.3	608.1	4.5	3.5	8 0	16.7	4 9	21.3
Sequoyah	5.2	99.1	104.3	---	.3	3	.2	1.4	1.6
AREA	1989.5	1918.8	3908.3	57.1	21.9	79.0	109.1	40.9	150.0

[1] U. S. D. A. Forest Service, *Forests of East Oklahoma,* 1955-56, Forest Survey Release 79, June, 1957.
[2] This study.
[3] Estimated as the average between allocating the totals by counties on a live saw-timber basis and on a sawmill output basis. The county where the timber grows is not necessarily the same as the county where a sawmill processes the timber.

equal share of the total output demanded the process towards such equilibrium involves large expenditures in new plant. In estimating optimum industry structure with a total output of 150,000 M.B.F. allowing for restrictions of location, care was taken to perform the minimum changes in plant and equipment possible. Existing sawmills in each county were adjusted to their most efficient outputs taking the largest existing firm first. In cases where the present mills at optimum output could not process the 1975 output potential for the county, new mills were added by moving mills up from one type to the next. In no case was a Type V mill added unless there was at least 4,000 M.B.F. of unprocessed output left after increasing the size of existing mills to that of Type IV. It is hoped that this procedure will give an insight into the capacity of the industry with minimum expenditure on new fixed plant.

Results

Table 17 illustrates the structure of the industry operating at potential 1975 outputs under the methods outlined above. In eight counties, a reduction of mills is possible, in two counties an increase is needed. These two counties, LeFlore and McCurtain, are, of course, the richest in forested land and will be expected to bear the brunt of output expansion.

In six counties an expansion in the size or structure of the local industry is needed to process the county potential. In these counties, six Type I sawmills, one Type II, and three Type III need to be expanded to Type IV mills. Also, there is needed a net addition of one Type II, seven Type IV, and two Type V mills to handle the 1975 output figure. But there is a net decrease in the area number of Type I mills of 35; of Type II, 9; and of Type III, 9. For the larger types, Type IV needs an increase of 16, and Type V of 2 mills. The total number of mills drops to 80 from 114 and much of the change in Types II and III could be handled by re-locating portable mills of these types.

It should be remembered that the new structure of the industry as dipicted here is not necessarily what will happen if 157,000 M.B.F. is processed in 1975. Many small part-time mills will remain and the mills of Type V now existing may well take a far larger proportion of the increase in output than estimated from existing data. It was demonstrated that the large mills are more flexible with respect to increasing output at declining unit costs. Nevertheless, the results do show that, with a relatively small reorganization in the structure of the industry, but with an increase in the operating time and a large increase in sawmill efficiency, an increase of nearly 50 percent in output could be achieved by only 80 sawmills. Thus, considering the 133 sawmills now present, the sawmill industry of Eastern Oklahoma may be said to be operating at much less than one-half capacity with respect to optimum structure, efficiency, and full-time operation given an estimated 156,900 M. B. F. of potential output from the local forests.

Table 17. Distribution by County of Estimated Number and Type of Sawmills Needed to Process 1975 Potential Output

COUNTY	1956 Actual Output	1975 Potential Output	Minimum Number of Mills[1]	1956 Actual[2] Sawmill by Type I	II	III	IV	V	T	1975 Optimum Mill Allocation[3] Number and Type I	II	III	IV	V	T	Processing[4] Potential
	—M.M.B.F.—															—M.M.B.F.—
Adair	2.4	3.6	2	6	6	3	2	–	17	–	–	1	2	–	3	4.1
Atoka	2.9	4.0	3	5	2	2	2	1	12	–	–	1	1	1	3	4.1
Cherokee	1.1	2.6	3	5	2	4	–	–	11	–	1	2	–	–	3	2.6
Choctaw	4.9	7.3	3	4	–	–	–	1	5	3	–	–	1	1	5	7.8
Coal	.4	1.1	1	3	–	–	–	–	3	3	–	–	–	–	3	1.2
Delaware	2.1	2.6	2	11	3	–	–	–	14	3	3	–	–	–	6	2.7
Haskell	.6	2.3	3	3	–	–	–	–	3	2	–	–	1	–	3	2.4
Latimer	2.0	3.6	3	1	1	–	2	–	4	1	1	–	2	–	4	4.0
LeFlore	5.8	16.2	6	–	–	2	3	1	6	–	–	1	4	2	8	16.2
McCurtain[5]	43.2	77.1	6	2	–	–	1	3	6	2	1	–	8	4	15	77.5
McIntosh	1.3	1.3	2	1	–	1	2	–	4	–	–	–	2	–	2	3.0
Muskogee	.6	1.5	2	3	–	–	–	–	3	1	–	–	1	–	2	2.0
Pittsburg	3.4	3.6	4	5	–	1	1	–	7	3	–	1	1	–	5	3.8
Pushmataha	8.0	21.3	5	3	1	2	8	–	14	–	–	–	14	–	14	21.3
Sequoyah	.3	1.6	2	2	3	–	–	–	5	1	3	–	–	–	4	2.0
AREA	79.0	150.0	47	54	18	15	21	6	114	19	9	6	37	8	80	154.7

[1] Minimum estimated from average length and breadth of county assuming no sawmill can afford to haul more than 15 miles.
[2] Nineteen sawmills with insufficient data eliminated.
[3] Allocated by following criteria:
- (1) No county can have less mills than indicated in [1].
- (2) Each county makes optimum use of its larger 1956 mill types in decreasing order.
- (3) Potential output of existing Type V firm used.
- (4) Where a new firm type is needed to supply total output required, Type IV is used unless the increased production is 4,000 M.B.F. or more. Then one Type V firm is added with the actual average of 4,000 M.B.F. output of gangsaw firms.

[4] To the area total should be added 2,000 M.B.F. from eliminated firms.
[5] The processing potential for McCurtain county assumes a greatly increased output of one large firm, which has already reorganized for this output increase, and includes the firm processing 4,000 M.B.F. which was eliminated for insufficient data.

Table 18. Summary of Results of Various Yearly Capacity Levels for the Sawmill Industry

Capacity Level	Firm Type	Total Output	No. of Sawmills	Output per Mill	No. of Workers	Output per Worker
		M.M.B.F.		*M.B.F./mill*		*M.B.F./man*
Actual 1956	I	5.5	54	102	137	40
	II	3.1	18	173	45	69
	III	2.9	15	191	54	53
	IV	13.9	21	660	113	123
	V	48.5	6	8,083	81	599
	Total[1]	78.9	133	593	479	165
200-Day Capacity[2] For firm types I to IV. Actual for others.	I	12.9	54	239	137	94
	II	4.9	18	271	45	108
	III	6.1	15	410	54	114
	IV	16.8	21	800	113	149
	V	48.5	6	8,083	81	599
	Total	95.2	133	716	479	199
Firm Capacity[2] At optimum efficiency for existing firms of Types I to IV	I	24.0	54	445	108	222
	II	9.1	18	506	54	169
	III	15.7	15	1,049	75	210
	IV	31.9	21	1,518	126	253
	V	48.5	6	8,083	81	599
	Total	135.2	133	1,017	493	274
Industry Capacity At "optimum" distribution of firm types by location to process at least 150 M.M.B.F.	I	8.4	19	445	38	222
	II	4.5	9	506	27	169
	III	6.3	6	1,049	30	210
	IV	56.2	37	1,518	222	253
	V	79.5	8	9,062	122	652
	Total	156.9	98	1,601	480	327

[1] Totals include eliminated firms with numbers, output and workforce unchanged.
[2] Type V firms held constant at actual 1956 figures since they are all working at least 200 days and close to optimum firm efficiency.

Summary of Capacity Results

Table 18 summarizes the results from the different types of capacity estimates studied. The changes in output possible under the different assumptions are compared with the firms and workers needed, together with the average mill and worker productivity. As would be expected, the output per mill and per man increases as we pass from actual to 200-day capacity. But the output per man also increases even with an increase in men at firm capacity. Men are being more efficiently used in this case. It should also be noted that the work force does not decline with increased efficiency even though the number of mills do in the case of industry capacity. Thus, the possible beneficial effects to the owners of forest resources of an expansion in sawmill output would not be necessarily balanced by a decrease in total employment through increased efficiency. These increases in sawmill output will also require concomitant increases in the output of secondary wood users such as planing mills who currently further process at least 30 percent of the sawmill output.

The fact that the sawmill industry is working at less than capacity by all measures used implies that there is no restriction placed by the industry on potential improvements in the economic welfare of local farm owners of forest land. This segment of the market for one specialty crop is leading development in low income agriculture.

CONCLUSIONS

The major conclusions of this study may be listed as follows:

A "Directory of Wood Industries in Eastern Oklahoma"[18] has made up-to-date market information available to buyer and seller.

The structure of the processing industry for forest products is highly diversified and, especially in the sawmill sector, rapidly changing. In numbers of firms and volume of wood processed, this industry is more important to the local economy than has been generally known.

There is a wide variation in the relative efficiency of sawmills of a given type of plant and equipment. Most of this variation can be attributed to sub-optimum levels of output. In general, the larger sawmills are more efficient in terms of unit total costs and can achieve relative efficiency over wider ranges of output levels. To attain this cost flexibility which larger and more expensive fixed plant makes possible, the large sawmills must process far more wood than the majority now handle. The largest type sawmills which use gangsaws are now operating at high levels of efficiency but some of them could benefit from greater volume sawn. These conclusions are based on observations of existing firms and need to be reinforced by case studies which combine engineering and economic considerations to determine the optimum equipment and its use for different levels of output.

The sawmill industry of Eastern Oklahoma is working at less than full capacity. By operating existing plant and equipment at least 200 days per year, the industry could increase its output by 22 percent. By using, in addition, this plant as efficiently as do the more efficient firms of a given type, sawmills could increase their volume by 71 percent. By a small degree of reorganization, with respect to plant size and location, in the structure of the industry, 80 of the present 133 sawmills could double present output and process the maximum requirements projected for 1975. A full appreciation of this reorganization would require, however, a more refined study of efficiency as outlined above coupled with an analysis of optimum location of the plants in the industry in regard to their sources of timber supply, their markets for processed lumber and the related costs of transportation.

Farmers own 31 percent of the privately owned commercial forest land of Eastern Oklahoma but their individual holdings are small. Although both farm and non-farm owners own about the same proportions of pine and hardwood, farmers sell relatively less pine from

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[18] E. J. R. Booth, Robert Raunikar and C. L. Clymer, "Directory of Wood Indutries in Eastern Oklahoma," Oklahoma State University Extension Service, Circular 663.

their less concentrated stands of softwood. The farm-owned share of the value of timber sold to the primary markets is only 21 percent, but it did amount to $859,000 in 1956—a significant portion of the total receipts to farming in this area where farm incomes are often severely low. Few changes in the sawmill industry would be needed to process increased output from farm woodlots.

Appendix Table 1. Estimated Regressions of Cost on Output by Firm Types and by Functional Forms Observed Over Eastern Oklahoma Sawmills

FIRM[1]		FUNCTION[2]		FUNCTIONAL AND STATISTICAL COEFFICIENTS[3]					
Type	c	Form	n	a	b	t_b	d	t_d	R^2
		A	54	5.110	3 593	2.566	–	–	.112
		B	54	1.786	— .00142	10.102	–	–	.662
I	124.2	C	54	3.504	— .8919	16.106	–	–	.833
		D	54	89.62	—348 1	6.298	351.9	4.567	.540
		E	31	36.40	— 72.64	3 387	53.40	2.197	.574
		S	54	4.006	— 1.157	— 7.866	.000502	1.915	.850
		A	18	5·342	3.270	1.198	–	–	.082
		B	18	1.828	— .00145	6.236	–	–	.708
II	131.2	C	18	3 540	— .9032	9.312	–	–	.844
		D	18	103.4	—447.8	6.037	504.7	4.701	.813
		E	9	29.57	— 48.51	.639	28 27	.307	.579
		T	18	3.883	— .0907	— .310	.000350	.682	.087
		S	18	3.886	— 1.087	— 3.801	.000339	.675	.855
		A	15	6.704	3.583	3.234	–	–	.446
		B	15	1.661	— .000562	3.704	–	–	.513
III	142.2	C	15	3.587	— .8770	10.955	–	–	.902
		D	15	99.09	—238.2	4.166	103.8	3.573	.629
		E	10	31.09	— 34.98	3.343	12.05	2.448	.823
		T	15	4.105	— .1297	— .981	.000253	2.250	.405
		S	15	4.110	— 1.128	— 8.684	.000249	2.260	.934
		A	21	8.605	4.988	2.863	–	–	.301
		B	21	1·604	— .000427	6.366	–	–	.681
IV	227.6	C	21	3.180	— .6844	8.131	–	–	.777
		D	21	55.80	— 68.50	3.402	24.20	2.366	.544
		E	18	27.71	— 13.74	1.109	1.471	2.259	.480
		T	21	3.099	.3520	1.514	—.000026	—.169	.426
		S	21	3.130	— .656	— 2.880	—.000025	—.167	.787

[1] Firm
Type: I to IV explained in text, standardized at 200 days.
c: Fixed cost in dollars per 200-day year.

[2] Function
Form: A; linear in total cost in dollars and output in M.B.F.
B; linear in logarithms of unit variable cost in dollars per M.B.F. and logarithms of output in M.B.F.
C; linear in logarithms of unit variable cost in dollars per M.B.F. and output in M.M.B.F
D; polynomial in unit variable cost in dollars per MB.F. and two degrees of output in M.M.B.F.
E; same as D for observed pairs with outputs greater than 200 M.B.F.
T; Transcendental with log of total variable cost in dollars per M.B.F. on log of output and output in M.B.F
S; Transcendental as in T with log of unit cost in dollars per M.B.F. as dependent variable.
n: Number of observations fitted.

[3] Coefficients: a; average intercept of cost.
b; average influence of output on cost.
t_b; "Student's" t-value of b coefficient.
d; average influence of squared output on cost.
t_d; same as for t_b.
R^2; proportion of cost variability explained by the fitted function.

Appendix Table 2. Estimated Coordinates of Minimum Unit Cost and Associated Output by Firm Types and by Method of Estimation

Firm Type[1]	Estimated Coordinate[2]	Method of Estimation[3] D	E	S	F	G
I	Output (M.B.F.)	495	683	1000	550	445
	Unit Cost (dollars/M.B.F.)	3.86	11.87	10.87	9.00	13.86
II	Output (M.B.F.)	444	861	1392	700	506
	Unit Cost (dollars/M.B.F.)	4.37	−2.44	8.76	10.50	12.50
III	Output (M.B.F.)	1148	1454	1935	2400	1049
	Unit Cost (dollars/M.B.F.)	—37.44	5.80	3.37	5.50	9.96
IV	Output (M.B.F.)	1418	4674	4	3000	1518
	Unit Cost (dollars/M.B.F.)	7.49	—4.33	4	3.50	9.18

[1] Types I to IV as explained in text.
[2] Minimum unit total cost and its associated output.
[3] D; Using a polynomial equation estimated as in Appendix Table 1.
$atc = cx^{-1} + a + bx + dx^2$ with atc a minimum at an output equal to the one positive real root of $x^2(2dx+b) = C$ where only b is negative.
E; As in D.

S; Using transcendental estimated as in Appendix (Table 1, $at^{c} = A \times b10^{d})$ with at^{e} minimum at $(x = -a)a/b.\ln 10$.
F; Freehand approximation of critical values.
G; First quintile average of output and output weighted average of unit total cost.
[4] The parameters estimated resulted in a function which was not critical in the positive domain. Functions AB and C of Appendix Table 1 cannot be used since they are not critical on any positive open interval. Function T was not examined for critical values of unit cost due to the unwieldy computations involved.

Estimated Coordinates of Industry Cost Curve

A long-run unit cost function was fitted by selecting, from the observations of all 114 sawmills excepting the one very large firm, pairs of unit total cost and output such that, for output greater than 200 M.B.F., the smallest unit total cost was selected from each 100 M.B.F. interval. This method was chosen in an attempt to approximate an envelope curve to the data The minimum cost coordinates from this estimation can then be compared with the observation from the one large firm standardized at 200 days' operation. These were 24,000 M.B.F. and $5.46 per M.B.F. The results were:

$AC = 17.66 - 7.566x + (1.222x^2)$

$R^2 = .539 \quad t_b = 3.42 \; t_d = 2.75$

Minimum AC of $5.94 per M.B.F. at 3095 M.B.F.

2-60/2M